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1999 Improved Ammonia Emission Inventory by County in Tennessee

Yunhee Kim

To the Graduate Council:

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Wayne T. Davis, Major Professor

We have read this thesis and recommend its acceptance:

Terry L. Miller, Joshua S. Fu

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

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1999 IMPROVED AMMONIA EMISSION INVENTORY BY

COUNTY IN TENNESSEE

A THESIS
PRESENTED FOR THE
MASTER OF SCIENCE
DEGREE
THE UNIVERSITY OF TENNESSEE, KNOXVILLE

YUNHEE KIM
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ABSTRACT

Ammonia gas reactions in the atmosphere are a significant source of $PM_{2.5}$ (particulate matter with an aerodynamic diameter less than 2.5um). Due to the increasing concentration of $PM_{2.5}$ in the atmosphere, the need for improved ammonia emission inventories has become an increasingly important air quality issue. This study produced ammonia emission estimates for ten source categories and fifty- four sub-source categories for the State of Tennessee on a county basis for the year 1999.

Livestock is a major source of total ammonia emissions in Tennessee, responsible for emitting 88,000 tons per year, with beef cows emitting 45,000 tons of ammonia emissions and forming the biggest sub-source category within the livestock category. Even though soil may be an uncertain source category of ammonia emissions and some double counting of emissions may occur in the fertilizer source category, soil was estimated to emit 61,000 tons of ammonia emissions as the second highest contributor. In some urban counties in Tennessee, mobile sources were the largest source of ammonia emissions.

Ammonia emissions were estimated on a county basis from 54 source categories for all counties in Tennessee. In addition, this study includes recommendations for the use of spatial surrogates to allocate emissions for area sources, and temporal profiles for allocating emissions by season and time of day. The spatial and temporal allocations of emissions are needed for modeling $PM_{2.5}$ formation.

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CHAPTER 1

INTRODUCTION

Gaseous ammonia is an important precursor pollutant that contributes to the formation of $PM_{2.5}$ (particulate matter with an aerodynamic diameter less than 2.5μm). Ammonia gas generated from various sources reacts chemically with nitric and sulfuric acid in the atmosphere. The chemical reactions form $PM_{2.5}$ that has effects on human health and visibility. Because of this, an ammonia emission inventory by county for the State of Tennessee is needed for modeling $PM_{2.5}$ formation.

The objective of the study is to develop an improved ammonia emission inventory by county for the State of Tennessee for the base year of 1999. Previous studies by CMU (Carnegie Mellon University) have generated an ammonia emission inventory for the State of Tennessee. Ammonia emissions in the CMU study (CMU, 2001) based on the years of 1995, 1996, and 1997 were found to lack information about several emission source categories such as human, soil, and mobile sources. NET99 (EPA's National Emission Trends, 1999), which also contains NH_3 inventory, was found to contain an incomplete emission inventory by county and lacked details about sub-source categories. The air quality research group at the University of Tennessee is involved in modeling $PM_{2.5}$ formation in Tennessee and surrounding states using a base year of 1999. To model $PM_{2.5}$ formation for the year of 1999, it is necessary to make improved ammonia emission inventory estimates by county in Tennessee.

This study presents 10 source categories and 54 sub-source categories for improved 1999 ammonia emission inventory estimates by county for the State of

Tennessee. Spatial and temporal allocations for sub-source categories for modeling $PM_{2.5}$ formation are also presented.

CHAPTER 2

BACKGROUND

A number of studies, reports, and papers were reviewed and used in estimating the 1999 ammonia emission inventory by county in Tennessee. This chapter provides an overview of the research conducted in preparation of the ammonia emission inventory. It is arranged as follows: (1) reactions of NH_3 in the atmosphere to form $PM_{2.5}$, (2) impact of particulate matter on humans and the surrounding environment, (3) existing ammonia inventories for Tennessee, and (4) the studies conducted to determine a nationwide ammonia inventory.

2.1 REACTIONS OF NH_3 IN THE ATMOSPHERE TO FORM $PM_{2.5}$

Ammonia is present even in unpolluted air as a result of natural biochemical and chemical processes. High concentrations of ammonia gas in the atmosphere are generally indicative of accidental release of the gas. Ammonia is removed from the atmosphere by its affinity for water and by its action as a base. It is a key species in the formation and neutralization of nitrate and sulfate aerosols in polluted atmosphere (Manahan, 1999).

Atmospheric chemical reactions convert NOx to nitric acid, inorganic nitrate salts, organic nitrates, and peroxyacetyl nitrate. The principal reactive nitrogen oxide species in the troposphere are NO, NO_2, and HNO_3. Nitrogen dioxide is a very reactive and significant species in the atmosphere and is ultimately removed from the atmosphere as nitric acid, nitrates as organic nitrogen. In the stratosphere, nitrogen dioxide reacts with hydroxyl radicals to produce nitric acid. In this region, the nitric acid can also be destroyed by hydroxyl radicals, or by a photochemical reaction, so that HNO_3 serves as a temporary sink for NO_2 in the stratosphere. Nitric acid produced from NO_2 is removed as precipitation, or reacts with bases (ammonia, particulate lime) to produce particulate nitrates (Manahan, 1999).

A common process for the formation of aerosol mists involves the oxidation of atmospheric sulfur dioxide to sulfuric acid that accumulates atmospheric water to form small liquid droplets. In the presence of basic air pollutants, such as ammonia the sulfuric acid reacts to form salts. Under low-humidity conditions water is lost from these droplets and a solid aerosol is formed (Manahan, 1999).

Ammonia gases emitted from a wide range of human-generated and natural sources react chemically with nitric acid and sulfuric acid in the atmosphere. An important role of ammonia in the atmosphere is neutralizing compounds such as nitric and sulfuric acids, formed as products of the atmospheric oxidation of NOx and SO_2 emissions, respectively (Kean et al., 2000). The summary equilibriums are as follows.

$NH_{3\,(g)} + HNO_{3\,(g)}$? $NH_4NO_{3\,(s)}$

$NH_{3\,(g)} + H_2SO_{4\,(g)}$? $NH_4HSO_{4\,(s)}$

The chemical reactions contribute to form $PM_{2.5}$ (particulate matter with an aerodynamic diameter less than 2.5 um). Ammonium nitrate and sulfate contribute significantly to fine particle mass and visibility problems (Chow et al., 1994;Larson et al., 1988). The transport of nitric acid is aided by the formation and condensation of ammonium nitrate on accumulation mode particles. Furthermore, dry and wet deposition of ammonia and ammonium is an important source of nutrients to some ecosystems (Pearson and Stewart, 1993). In the situation of high ammonia and nitric acid concentrations and low sulfate concentrations in the atmosphere, gaseous ammonia can react to form ammonium nitrate.

In the presence of sulfate concentrations, gaseous ammonia can react to form ammonium sulfate. Gaseous SO_2 reacts with the hydroxyl radical resulting in the formation of sulfuric acid. Whether reacted with nitric or sulfate acid, the ammonium ion (NH_4^+) is often regarded to be an important factor associated with tropospheric aerosols (TX Report 2000).

Global ammonia emissions were estimated to be 45 million metric tons per year, with approximately two- thirds of this total being attributed to human-generated sources. Almost one-half of total ammonia emissions were attributed to animal husbandry. Ammonia is the most influential gaseous base in the atmosphere and a main neutralizing factor for atmospheric acids. The NH_3 in the atmosphere may control the acidity of precipitation (Dentener and Crutzen, 1994).

Ammonia-mixing ratios generally range from 0.1 to 10 parts per billion by volume (ppb). Additionally, tropospheric concentrations of ammonia are highly changeable and dependent on closeness to sources, source strengths (mass emission rates), meteorological conditions, and those mechanisms that remove NH_3 from the atmosphere. Furthermore, the combined effects of these removal processes lead to typical atmospheric residence times on the order of 10 days for NH_3 (Seinfeld and Pandis, 1998).

2.2 THE IMPACT OF PARTICULATE MATTER ON HUMANS AND THE SURROUNDING ENVIRONMENT

The impact of particulate matter on humans and surrounding environment is highly affected by the particle size distribution. These fine particles such as ammonium sulfates and ammonium nitrates are known to produce negative health effects as well as reduced visibility. For example, these fine particulates can penetrate deep into the respiratory system where they can do damage in several ways. These fine particles might be toxic due to their chemical and physical form. They might be carriers of toxic materials that are adsorbed on their surfaces and can be transferred into the blood stream. Such particles may also interfere with one or more mechanisms associated with the normal clearance of the respiratory tract (Corsi et al., 2000).

In a study involving mortality rates in six US cities, researchers at Harvard University observed a statistically significant correlation between increased $PM_{2.5}$ concentrations and increased mortality (Schwartz et al., 1996).

Ammonia also interacts with regional and global atmospheric sulfur cycles, thus having a potential impact on regional visibility and global warming. $PM_{2.5}$ as the secondary fine particulate matter that is formed by reactions involving ammonia are a growing concern in terms of impacts on human health (Bouwman et al., 1997).

Neutralization products such as ammonium bisulfate, ammonium sulfate, and ammonium nitrate are known to be significant constituents of atmospheric aerosols, including cloud condensation nuclei (Dawson, 1977).

2.3 EXISTING AMMONIA INVENTORIES FOR TENNESSEE

In most regions, ammonia emission inventories will be needed to better understand the formation and fate of particulate matter. Therefore it is important to generate ammonia emission estimates using source categories and sub-source categories from various sources. There are several studies that have attempted to estimate ammonia emissions. This section presents a summary of the CMU studies (CMU, 2001) and NET

99 data (NET, 1998), both of which have developed ammonia inventories for the State of Tennessee.

2.3.1. CMU (Carnegie Mellon University) Inventory

The CMU study (CMU, 2001) generated ammonia emission estimates for the U.S. on a state-by-state basis. Fig 2-1 shows a pie chart from the CMU inventory (CMU, 2001) for the State of Tennessee. There were 9 source categories and 36 sub-source categories for annual emission estimates in the inventory. Table 2-1 provides a list of ammonia source categories and sub-source categories used in the CMU inventory.

The CMU inventory for the State of Tennessee shows that the major source of ammonia emissions is livestock. Activity levels for livestock were obtained from the USDA for 1997 (USDA, 1999). Emission factors for each USDA (USDA, 1999) category were obtained from Battye et al., 1994. Fertilizer application was found to be the second most significant source of ammonia emissions. The CMU inventory estimated the contribution from fertilizer application to be 12% of the statewide emissions.

Activity level data for fertilizer application were obtained from AAPFCO (the Association of American Plant and Food Control Officials) for 1995, which reported fertilizer sales to farmers at the county level. There were 13 sub-source categories in the fertilizer application source category used in the CMU inventory. Emission factors for these 13 were obtained from Battye et al., 1994. Ammonia emissions from fertilizer application have a strong temporal component that has previously been ignored. An

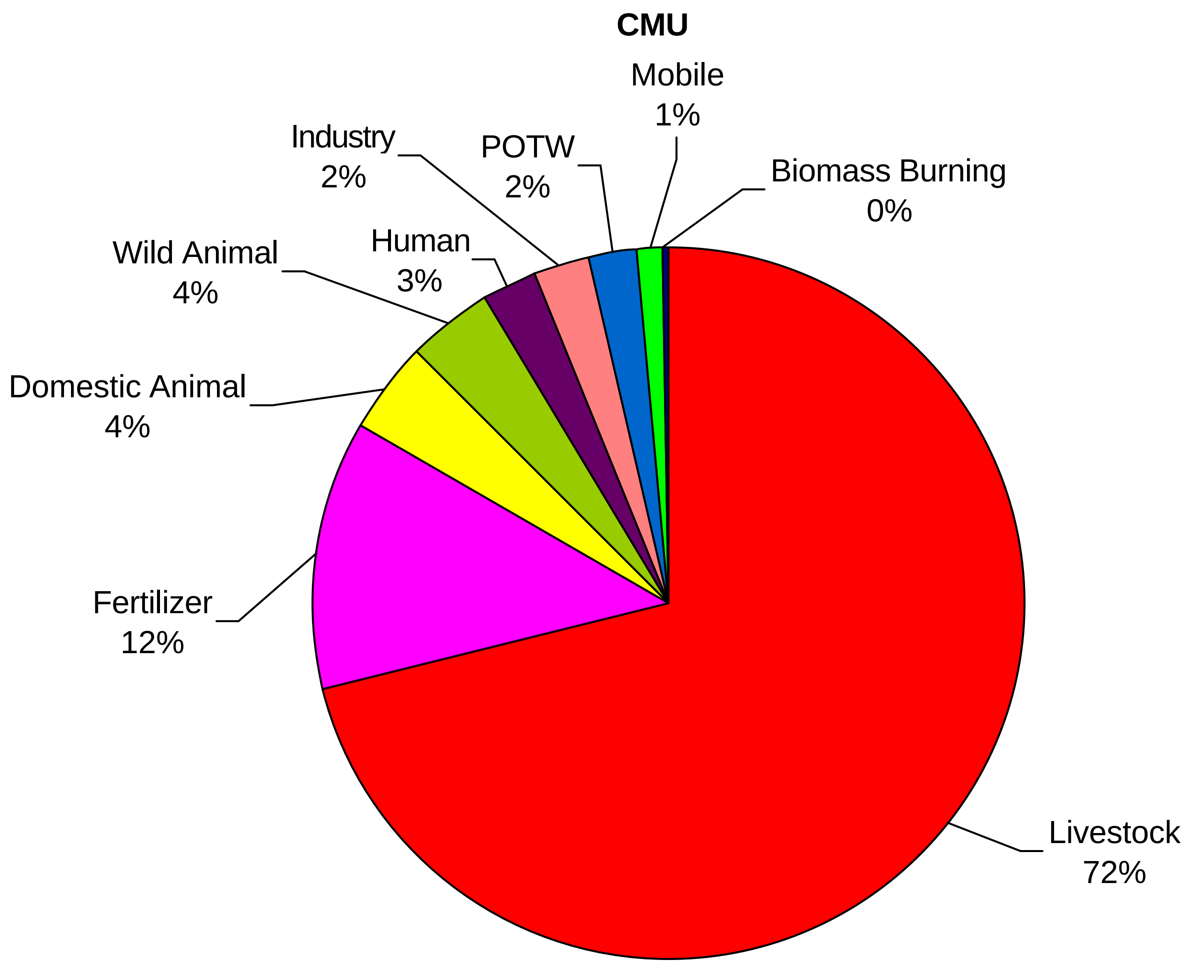

Fig 2-1. Pie Chart of Ammonia Emission Estimates from CMU Inventory in Tennessee by Source

Table 2-1. Source, Sub-Source Category, and Emission Factors in CMU Inventory

Source Category	Sub-Source Category	Emission Factor	Units
Livestock	Milk Cows	39.72	kgNH3/cow/yr
	Beef Cows	39.72	kgNH3/cow/yr
	Heifers and Heifer Calves	13.04	kgNH3/heifer/yr
	Steers,Steer Calves,Bulls, and Bull Calves	8.22	kgNH3/steer/yr
	Hogs and Pigs	9.2	kgNH3/pig/yr
	Horses and Ponies	12.2	kgNH3/horse/yr
	Sheep and Lambs	3.37	kgNH3/sheep/yr
	Angora Goats	6.4	kgNH3/goat/yr
	Milk Goats	6.4	kgNH3/goat/yr
	Pullets	0.269	kgNH3/pullet/yr
	Layers	0.598	kgNH3/Layer/yr
	Broilers	0.167	kgNh3/broiler/yr
	Turkeys	0.858	kgNH3/turkey/yr
	Geese	0.89	kgNH3/goose/yr
	Ducks	0.117	kgNH3/ducks
Human	Human	0.44	kgNH3/person/yr
Fertilizer	Anhydrous Ammonia	0.01	percent N released to atmosphere
	Ammonium_Nitrate	0.02	percent N released to atmosphere
	Ammonium_Sulfate	0.08	percent N released to atmosphere
	Ammonium_Thiosulfate	0.025	percent N released to atmosphere
	Calcium_Ammonium_Nitrate	0.02	percent N released to atmosphere
	Nitrogen_Solutions	0.08	percent N released to atmosphere
	Urea	0.15	percent N released to atmosphere
	Diammonium_Phosphate	0.04	percent N released to atmosphere
	Monoammonium_Phosphate	0.04	percent N released to atmosphere
	Liquid_Ammonium_Polyphosphate	0.04	percent N released to atmosphere
	Potassium_Nitrate	0.02	percent N released to atmosphere
	Miscellaneous	0.15	percent N released to atmosphere
	Mix	0.04	percent N released to atmosphere
Mobile	Cars	1.35E-05	kgNH3/VMT/yr
	Trucks	6.83E-05	kgNH3/VMT/yr
POTW			
Industry			
Domestic Animals	Dogs	2.18	kgNH3/dog/yr
	Cats	0.69	kgNH3/cat/yr
Wild Animals	Deers	4.54	kgNH3/deer/yr
	Bears	4.54	kgNH3/bear/yr
Biomass Burning	Fire_NH3	0.012	moleNH3/moleCO
	Fire_CO	140	lbsCO/ton wood burned
9 Source Category	36 Sub-Source Category		

important point here is that fertilizer application times and rates were used to generate a monthly distribution of fertilizer application.

Soil is believed to be the most uncertain category in an ammonia emission inventory, but has the capacity to be one of the top two sources. A 1990 inventory for the San Joaquin Valley in California estimated soil emissions to be 40% of the total. Gharib and Cass, 1982 used Anderson land use codes as activity levels for soil emissions, but the emission factors reported by Gharib and Cass, 1982 were very uncertain. Because of this, the CMU inventory simply did not include emissions from soil.

To estimate emissions for mobile sources in the CMU inventory, activity data were obtained from the various state transportation departments in the form of vehicle miles traveled per year for each county. The dates for this data ranged from 1995 to 2000. The CMU inventory indicated that the mobile source category was a minor source for ammonia emissions. However, higher percentages of the county total might be assigned to the urban areas.

Ammonia emission levels for the industry source category were obtained from the TRI (TRI, 1999). Because actual ammonia emissions for industry were reported in EPA's TRI database, emission factors were not needed for this category.

Ammonia emissions from wastewater treatment plants were not included in the TRI. Activity levels for POTWs (Publicly Owned Treatment Works) were obtained from EPA (EPA, 2000).

Ammonia emissions from human breath and perspiration were determined to be a few percent of the national ammonia emission inventory. Activity levels for the human source category were obtained from the US Census (U.S.Census, 1999).

Emission estimates for domestic animals and wild animals were obtained from the American Medical Association (Ammerican Veterinary Medical Association, 1997), the Quality Deer Management Association (Quality Deer Elk Association, 2000), and the American Bear Association (Ammerican Bear Association, 1993), respectively.

To estimate ammonia emissions from biomass burning, the number of acres burned was multiplied by typical fuel loading for that region of the country, and then an emission factor. Data for the number of acres burned were obtained from the National Interagency Fire Center for 1994. Typical fuel loading amounts were obtained from EPA and an emission factor was calculated by combining an emission factor for CO from forest fires (EPA, 2000) and a ratio of NH_3/CO measured from forest fires (Hegg et al., 1998). The emission factor and ratio of NH_3 to CO used in the CMU inventory were 140 lb CO per ton wood burned and 0.012 mole NH_3 per mole CO, respectively.

Fig 2-2 and Fig 2-3 show total ammonia emission estimates by county for the State of Tennessee based on the CMU NH_3 inventory. The Figs were prepared using the software ArcGIS (ArcGIS 8.1, 2001). Table 2-2 presents ammonia emission estimates for the 36 sub-source categories by county in Tennessee.

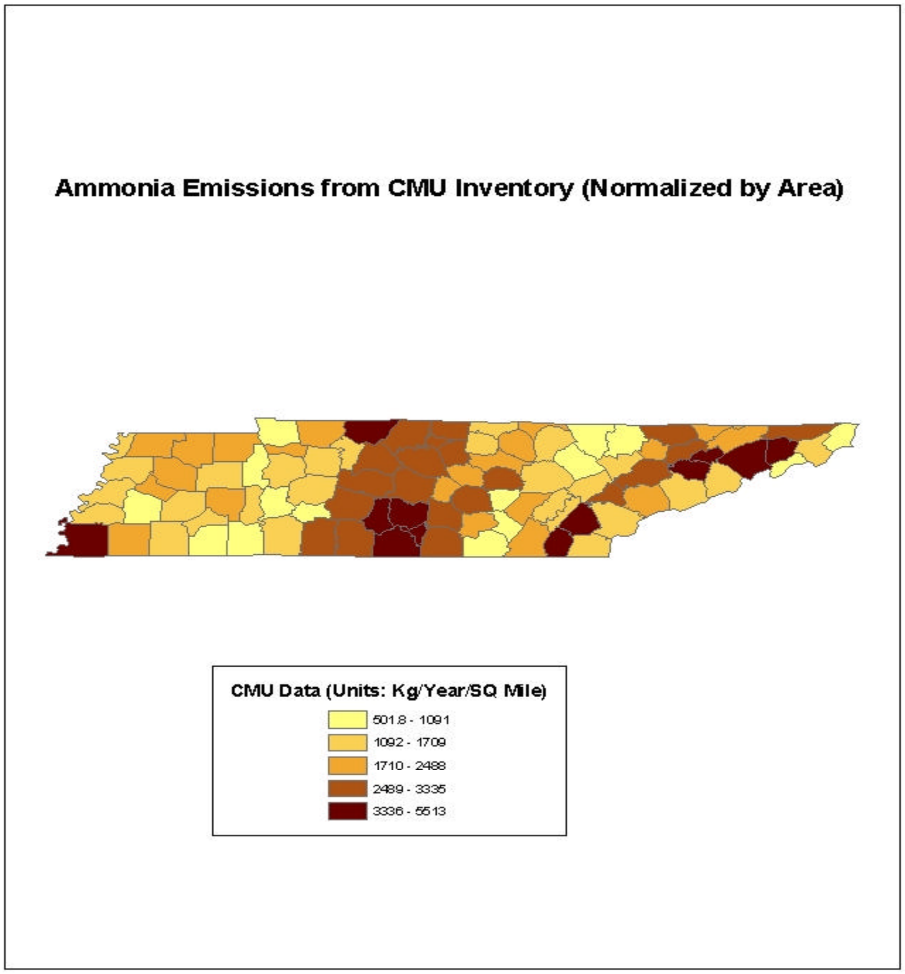

Fig 2-2. Total Ammonia Emission Estimates in CMU Inventory (Normalized by Area)

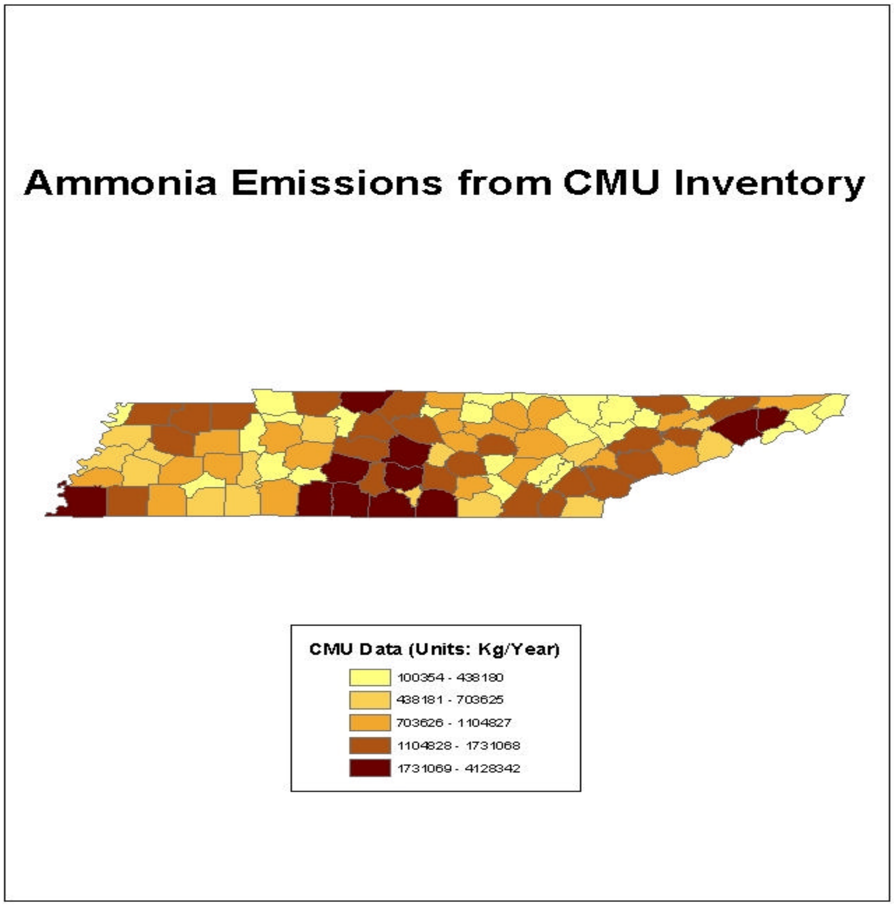

Fig 2-3. Total Ammonia Emission Estimates in CMU Inventory (in kg/yr by county)

Table 2-2. Ammonia Emission Summary for Tennessee in CMU Inventory

Source Category	Sub-Source Category	Ammonia Emissions	Units
Livestock	Milk Cows	4,903.13	ton/yr
	Beef Cows	45,516.89	ton/yr
	Heifers and Heifer Calves	7,200.67	ton/yr
	Steers,Steer Calves,Bulls, and Bull Calves	4,466.08	ton/yr
	Hogs and Pigs	3,263.52	ton/yr
	Horses and Ponies	1,197.12	ton/yr
	Sheep and Lambs	51.16	ton/yr
	Angora Goats	5.63	ton/yr
	Milk Goats	27.37	ton/yr
	Pullets	244.58	ton/yr
	Layers	1,090.38	ton/yr
	Broilers	3,281.72	ton/yr
	Turkeys	2.37	ton/yr
	Geese	2.82	ton/yr
	Ducks	1.31	ton/yr
	Total	**71,254.74**	ton/yr
Human	Human	**2,606.08**	ton/yr
Fertilizer	Anhydrous Ammonia	763.05	ton/yr
	Ammonium_Nitrate	4,002.50	ton/yr
	Ammonium_Sulfate	34.19	ton/yr
	Ammonium_Thiosulfate	0.23	ton/yr
	Nitrogen_Solutions	947.01	ton/yr
	Urea	2,612.26	ton/yr
	Diammonium_Phosphate	2121.9	ton/yr
	Monoammonium_Phosphate	13.2	ton/yr
	Liquid_Ammonium_Polyphosphate	26.55	ton/yr
	Potassium_Nitrate	2.96	ton/yr
	Miscellaneous	159.31	ton/yr
	Mix	1,442.22	ton/yr
	Total	**12,125.38**	ton/yr
Mobile	Cars	749.88	ton/yr
	Trucks	381.38	ton/yr
	Total	**1131.26**	ton/yr
POTW		**2321.77**	ton/yr
Industry		**2467.59**	ton/yr
Domestic Animals	Dogs	3477.20	ton/yr
	Cats	921.84	ton/yr
	Total	**4399.04**	ton/yr
Wild Animals	Deers	3703.12	ton/yr
	Bears	5.00	ton/yr
	Total	**3,708.12**	ton/yr
Biomass Burning	Fire_NH3	**202.18**	ton/yr
Total		**100,216.16**	ton/yr
Total		**91,013,811.11**	kg/year

2.3.2. NET 99 Tier (EPA's National Emission Trends Tier, 1999)

The search began with a review of ammonia emissions that had previously been reported in the US Environmental Protection Agency's National Emission Trends Tier Report for the year of 1999 (NET 99 Tier). The NET 99 Tier report provided emission estimates for ammonia sources in Tennessee. However, it was found to underestimate ammonia emissions for point sources and it had no breakdown of area sources such as livestock, fertilizer, and soil sources when compared to the CMU inventory. The NET99 Tier inventory only classified 3 source categories (area, mobile and point sources) with SCCs (Source Classification Codes). The SCCs in each source category (area, point and mobile) were not found to be complete. For example, the SCCs in the area source category only included sub-source categories of on-highway and off-highway vehicles (diesel or gasoline), railroad equipment, construction and mining equipment. Sub-source categories for livestock and fertilizer, typically considered to be the major sources in an ammonia emission inventory, were not even included in the NET99 inventory.

Fig 2-4 shows a pie chart from NET99 ammonia emission inventory for the State of Tennessee. It underestimates emissions from point sources showing only 89 tons per year. Table 2-3 presents ammonia emission estimates by county for 3 source categories in Tennessee showing a total of 82,260 tons per year compared to over 100,000 tons per year for the CMU inventory.

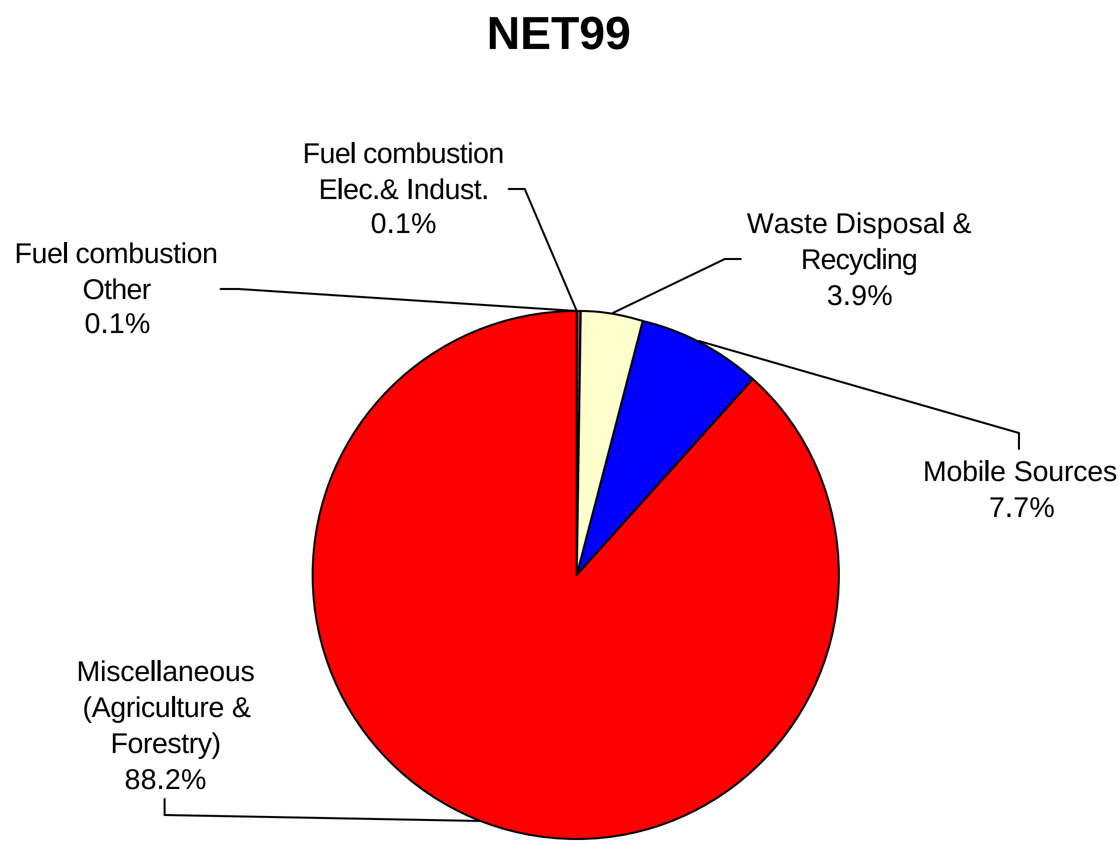

Fig 2-4. Pie Chart of Ammonia Emissions in NET99 for Tennessee

Table 2-3. Ammonia Emissions by Source for Tennessee

Source Category	Ammonia Emissions	Units
Area	75,811	Ton/yr
Mobile	6,360	Ton/yr
Point	89	Ton/yr
Total	82,260	Ton/yr

2.4. THE STUDIES CONDUCTED TO DETERMINE A NATIONWIDE AMMONIA INVENTORY

The SAMI (the Southern Appalachian Mountains Initiative) studies and the United States (U.S.) Environmental Protection Agency's (EPA) ammonia emission estimates of national emissions for 1990 to 1998 are two other inventories that have been conducted to determine ammonia emissions nationwide.

2.4.1. National Air Pollutant Emission Trends: 1990-1998

The trends report (NET, 1998) provides the United States (U.S.) Environmental Protection Agency's (EPA) estimates of national emissions for $PM_{2.5}$ as well as ammonia for the years of 1990 to 1998. EPA developed estimates for $PM_{2.5}$ and NH_3 starting with 1990.

The report shows that NH_3 has shown a modest increase during the 8-year period. Fig 2-5 shows the trend in ammonia emissions from 1990 to 1998. This Fig shows that ammonia emissions have increased steadily every year. Fig 2-6 is a pie chart showing ammonia emissions by source category. As the Fig shows, livestock contributes the largest amount of NH_3 emissions nationwide. Livestock and fertilizer application combined comprise 86% of total national ammonia emissions in 1998.

Table 2-4 shows anthropogenic 1998 state-level emissions and rank for NH_3. Tennessee was ranked 25th in state-level ammonia emissions, estimated at 83,000 tons per year. As mentioned previously, ammonia emission estimates for the year 1999 were estimated at 82,260 tons in Tennessee

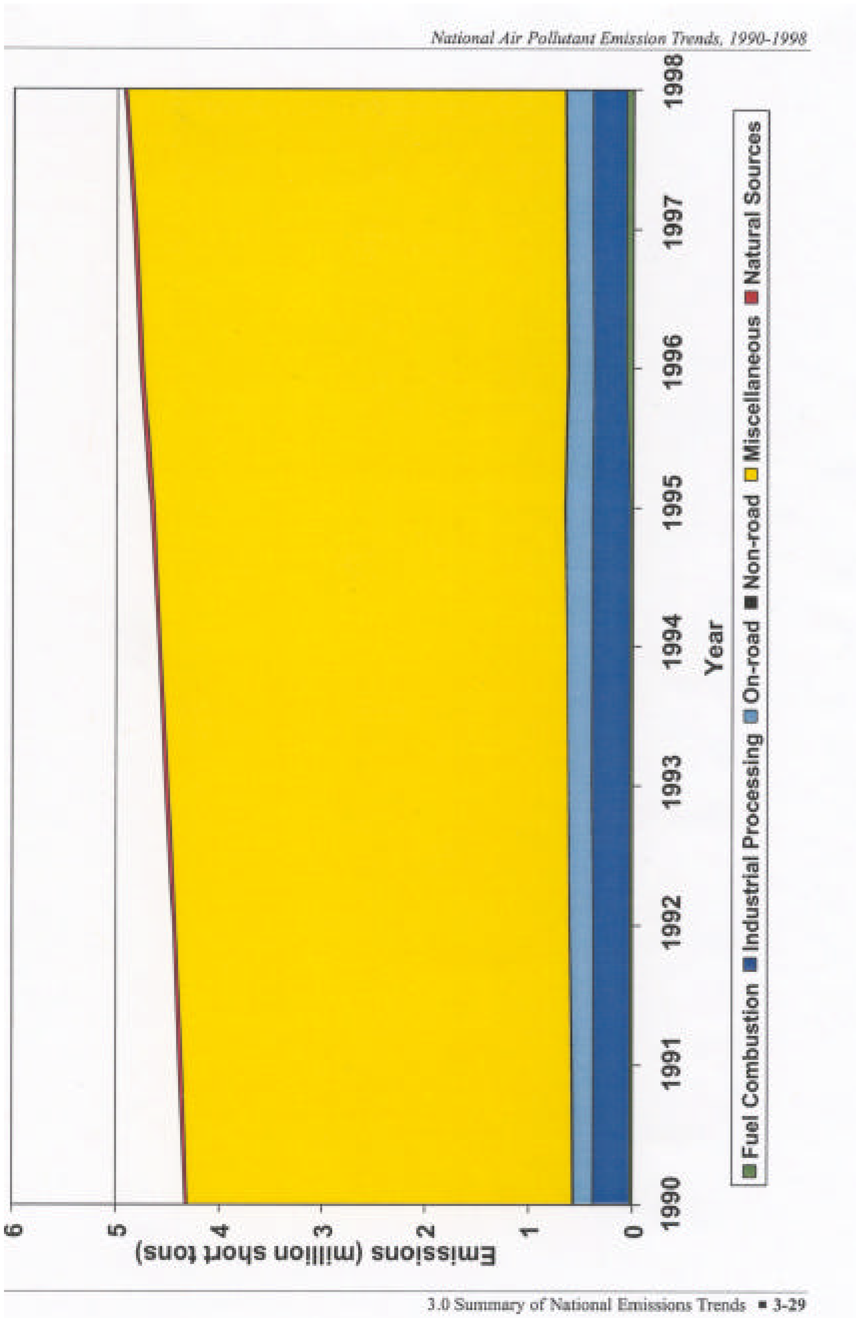

Fig 2-5. Trend in Ammonia Emissions, 1990 to 1998

Source: NET. (1998). National Air Pollutant Emission Trends: 1990-1998. http://www.epa.gov/ttnchie1/trends98/trends98.pdf.

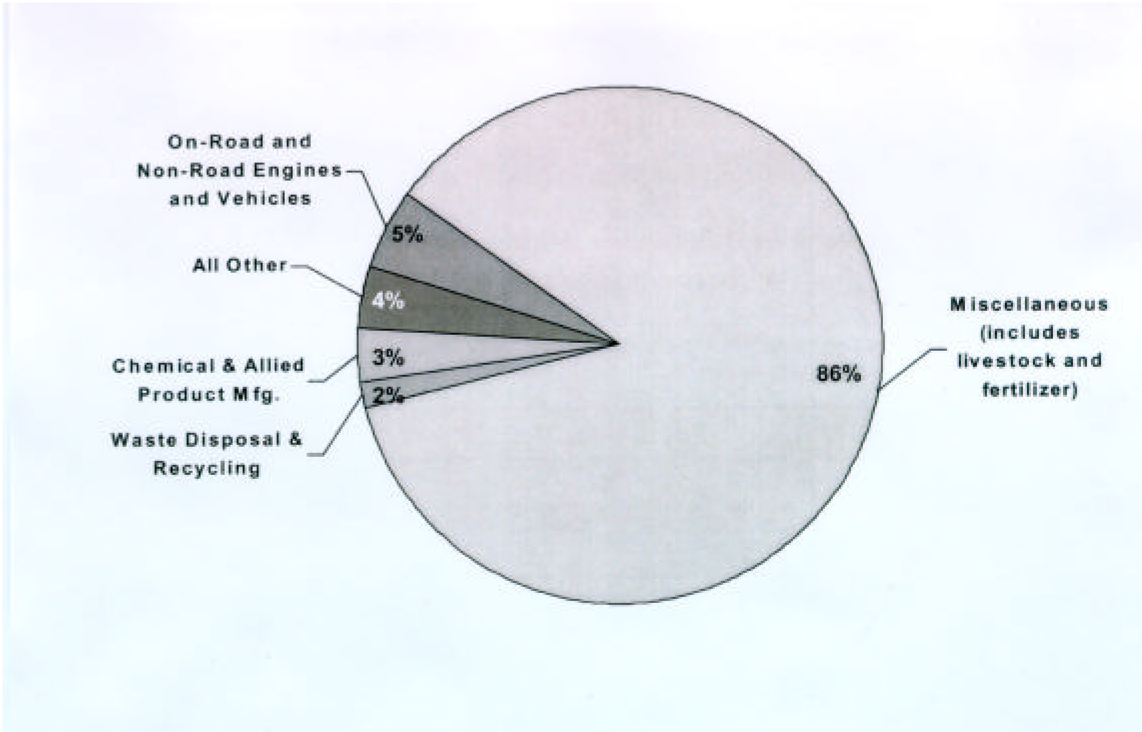

Fig 2-6. 1998 National Ammonia Emissions by Source Categories

Source: NET. (1998). National Air Pollutant Emission Trends: 1990-1998.
http://www.epa.gov/ttnchie1/trends98/trends98.pdf.

Table 2-4. Anthropogenic 1998 State-level Emissions and Rank for NH_3

(Thousand short tons)

State	Rank	CO	Rank	NO_x	Rank	VOC	Rank	SO_2	Rank	PM_{10}	Rank	$PM_{2.5}$	Rank	NH_3
Alabama	12	2,361	15	619	16	419	9	764	19	619	15	184	24	88
Alaska	13	2,249	44	99	14	457	50	12	39	274	19	155	51	1
Arizona	27	1,370	23	450	26	281	26	225	36	336	24	145	36	35
Arkansas	31	1,147	35	267	32	223	36	125	23	529	25	132	10	161
California	1	8,072	2	1,456	2	1,215	28	182	3	1,973	3	535	7	211
Colorado	29	1,200	25	400	27	274	35	137	24	518	29	126	15	111
Connecticut	37	793	41	153	35	156	41	66	45	119	45	30	45	8
DC	51	100	51	23	51	22	51	11	51	6	51	2	50	2
Delaware	50	216	47	77	48	51	37	96	48	39	48	14	43	12
Florida	3	5,203	5	1,059	3	891	6	1,008	11	822	7	260	22	94
Georgia	4	3,998	12	730	9	576	13	660	7	1,103	4	320	17	106
Hawaii	47	321	48	59	47	53	47	35	49	35	49	11	47	7
Idaho	34	956	43	116	39	115	46	39	14	678	17	161	27	78
Illinois	9	2,890	4	1,076	6	748	4	1,153	9	1,028	6	261	11	148
Indiana	11	2,526	7	848	12	518	3	1,164	17	641	20	154	18	104
Iowa	33	1,045	30	343	31	239	23	283	20	602	27	130	2	305
Kansas	28	1,230	20	479	30	257	30	163	4	1,570	5	299	4	232
Kentucky	26	1,389	14	682	23	330	10	753	35	345	35	103	21	95
Louisiana	14	2,184	9	825	15	425	16	405	27	441	23	149	13	130
Maine	42	488	45	94	40	109	44	53	42	158	36	102	46	8
Maryland	32	1,107	29	344	33	183	19	339	41	227	42	57	38	28
Massachusetts	30	1,188	31	304	29	264	24	264	38	290	40	72	42	14
Michigan	7	3,309	6	880	4	765	14	628	21	569	21	153	29	70
Minnesota	22	1,552	21	476	19	381	31	162	10	1,011	10	222	8	198
Mississippi	25	1,414	28	353	24	304	21	305	26	458	26	130	23	91
Missouri	19	1,816	16	546	20	360	15	482	5	1,286	8	252	6	221
Montana	39	703	39	176	42	105	42	60	6	1,137	12	216	19	96
Nebraska	40	681	36	239	36	154	38	94	18	632	30	125	3	241
Nevada	41	520	40	157	43	98	40	66	44	143	44	39	40	17
New Hampshire	45	355	46	82	45	74	34	148	47	54	47	17	48	3
New Jersey	24	1,454	22	466	17	408	25	257	37	313	37	96	41	15
New Mexico	36	855	32	279	38	140	27	199	1	4,987	1	781	34	49
New York	6	3,337	13	723	5	753	12	688	12	767	11	222	30	69
North Carolina	10	2,773	11	745	8	605	11	729	25	501	16	172	9	183
North Dakota	43	380	37	235	41	105	20	327	29	430	38	92	26	79
Ohio	5	3,934	3	1,198	7	706	1	1,921	16	658	13	195	16	111
Oklahoma	23	1,518	24	440	25	295	32	157	8	1,033	14	193	5	222
Oregon	18	1,988	33	271	28	272	43	58	13	686	9	224	31	65
Pennsylvania	8	2,909	8	840	10	575	2	1,221	22	547	18	156	20	96
Rhode Island	49	221	50	35	49	49	49	12	50	25	50	8	49	2
South Carolina	20	1,638	26	367	22	334	22	290	30	410	34	112	37	33
South Dakota	46	333	42	119	44	78	45	53	34	349	39	73	12	132
Tennessee	16	2,037	10	761	11	528	7	789	33	375	28	130	25	83
Texas	2	5,644	1	2,140	1	1,388	5	1,096	2	3,655	2	733	1	511
Utah	35	942	38	233	34	161	39	79	40	238	41	69	35	36
Vermont	48	240	49	46	50	44	48	16	46	75	46	18	44	10
Virginia	15	2,149	17	532	13	471	18	373	31	409	32	118	28	73
Washington	17	2,035	27	364	21	347	33	155	28	430	22	149	32	59
West Virginia	38	721	18	500	37	141	8	787	43	152	43	50	39	19
Wisconsin	21	1,600	19	480	18	400	17	378	32	391	33	112	14	124
Wyoming	44	361	34	270	46	68	29	179	15	663	31	122	33	53
National		89,454		24,454		17,917		19,647		34,741		8,379		4,935

Note(s): The sums of States may not equal National totals due to rounding.

Source: NET. (1998). National Air Pollutant Emission Trends: 1990-1998. http://www.epa.gov/ttnchie1/trends98/trends98.pdf.

Table 2-5 shows total national emissions of ammonia and source categories, 1990 through 1998. The total amount of national ammonia emissions was 4,935,000 tons per year. Fig 2-7 and Fig 2-8 show a density map of 1998 ammonia emissions by county and 1998 particulate matter ($PM_{2.5}$) emissions by county, respectively. The USDA (USDA, 1997) and EPA were reported to be working to improve the NH_3 inventory for all source categories, including some natural and biogenic categories that were not in the inventory. As mentioned above, the ammonia inventory is shown to be associated with ambient $PM_{2.5}$ (particulate matter with an aerodynamic diameter less than 2.5 µm).

Table 2-5. Total National Emissions of Ammonia, 1990 through 1998 (Thousand short tons)

Source Category	1990	1991	1992	1993	1994	1995	1996	1997	1998
FUEL COMB. ELEC. UTIL.	*0*	*0*	*0*	*0*	*0*	*0*	*6*	*7*	*8*
FUEL COMB. INDUSTRIAL	*17*	*17*	*17*	*18*	*18*	*18*	*49*	*48*	*47*
FUEL COMB. OTHER	*8*	*8*	*8*	*8*	*8*	*8*	*7*	*7*	*6*
CHEMICAL & ALLIED PRODUCT MFG	*183*	*183*	*183*	*183*	*183*	*183*	*158*	*160*	*165*
METALS PROCESSING	*6*	*6*	*6*	*6*	*6*	*6*	*5*	*5*	*5*
PETROLEUM & RELATED INDUSTRIES	*43*	*43*	*43*	*43*	*43*	*43*	*34*	*35*	*35*
OTHER INDUSTRIAL PROCESSES	*38*	*38*	*39*	*39*	*40*	*40*	*43*	*44*	*44*
SOLVENT UTILIZATION	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
STORAGE & TRANSPORT	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*1*	*1*
WASTE DISPOSAL & RECYCLING	*82*	*86*	*89*	*93*	*93*	*93*	*84*	*84*	*86*
ON-ROAD VEHICLES	*192*	*205*	*217*	*227*	*239*	*259*	*231*	*240*	*250*
NON-ROAD ENGINES AND VEHICLES	*6*	*7*	*7*	*7*	*7*	*7*	*9*	*10*	*10*
NATURAL SOURCES	*30*	*29*	*28*	*29*	*30*	*31*	*32*	*33*	*34*
Biogenic	30	29	28	29	30	31	32	33	34
MISCELLANEOUS	*3,727*	*3,770*	*3,814*	*3,869*	*3,924*	*3,979*	*4,113*	*4,163*	*4,244*
Agriculture & Forestry	3,727	3,770	3,814	3,869	3,924	3,979	4,113	4,163	4,244
livestock agriculture	*3,307*	*3,324*	*3,341*	*3,370*	*3,399*	*3,427*	*3,456*	*3,485*	*3,520*
fertilizer application	*420*	*446*	*473*	*499*	*525*	*551*	*657*	*678*	*724*
TOTAL ALL SOURCES	4,331	4,390	4,449	4,521	4,589	4,665	4,772	4,837	4,935

Note(s): NA = not available. Zero values represent less than 500 short tons/year.
Categories displayed below Tier 1 do not sum to Tier 1 totals because they are intended to show major contributors.
In order to convert emissions to gigagrams (thousand metric tons), multiply the above values by 0.9072.

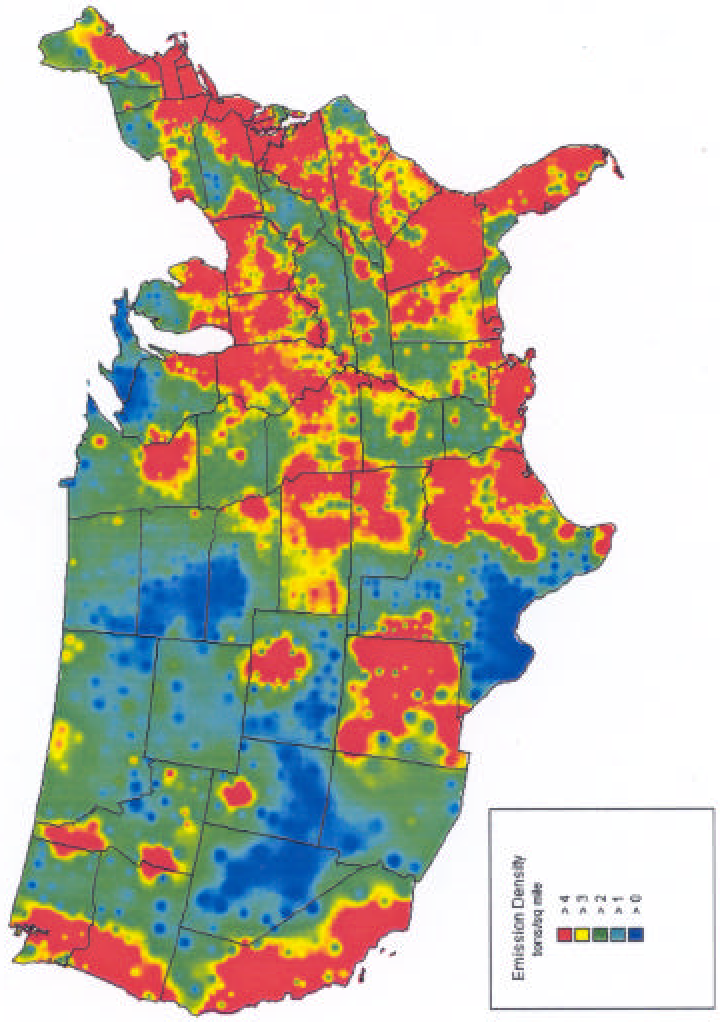

Fig 2-7. Density Map of 1998 Ammonia Emissions by county

Source: NET. (1998). National Air Pollutant Emission Trends: 1990-1998. http://www.epa.gov/ttnchie1/trends98/trends98.pdf.

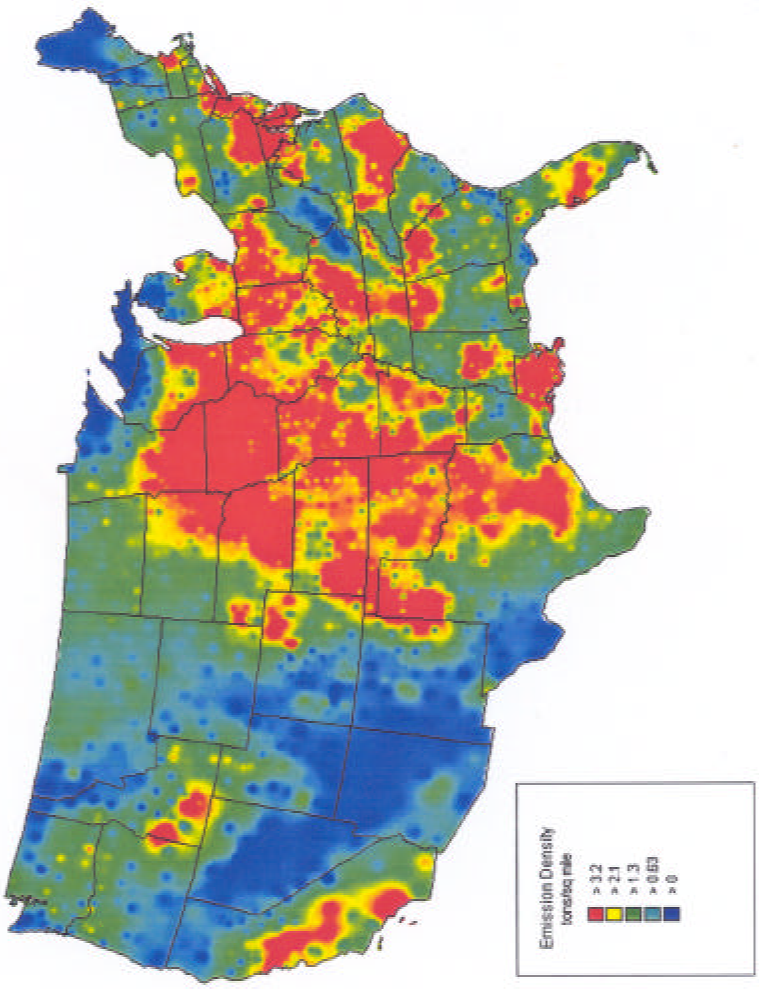

Fig 2-8. Density Map of 1998 Particulate Matter ($PM_{2.5}$) Emissions by County

Source: NET. (1998). National Air Pollutant Emission Trends: 1990-1998. http://www.epa.gov/ttnchie1/trends98/trends98.pdf.

2.4.2. SAMI (The Southern Appalachian Mountains Initiative) Inventory

In 1992, the Southern Appalachian Mountains Initiative (SAMI) was created in response to concerns about permitting new emissions sources near Class I national parks and wilderness areas in the Southern Appalachian Mountains (Class I refers to certain national parks and wilderness areas). Eight southeastern states were encompassed within the SAMI boundaries: Tennessee, Virginia, Georgia, Kentucky, North Carolina, South Carolina, Alabama, and West Virginia. SAMI inventories were developed to evaluate the emissions that contribute to ozone, fine particles and acid deposition for current and future years out to 2040 (SAMI, 2000).

The SAMI inventories (SAMI, 2000) included 10 emission categories and the major pollutants of concern included ammonia (NH_3); particles less than 10 and 2.5 microns (PM_{10} and $PM_{2.5}$), nitrogen oxides (NOx), sulfur dioxide (SO_2), and volatile organic compounds (VOCs). Annual inventories were developed for each of the SAMI emissions reduction strategies for 1990, 2010, and 2040. Assuming application of the OTW (On the Way) strategy, SAMI studies predict for 2010 and 2040 that SO_2 and NOx emissions will decrease, while VOCs, fine particles, and NH_3 will increase.

Fig 2-9 shows emissions in the eight SAMI states in 1990 and projected for 2010, and 2040 for the reference strategy OTW. This Fig shows that the total ammonia emissions per year between 1990 and 2010 from the eight SAMI states are approximately 600, 000 tons per year. The total ammonia emissions reported for 1998 state-level ammonia emission inventory (Table 2-4) from the eight states (Virginia, Georgia,

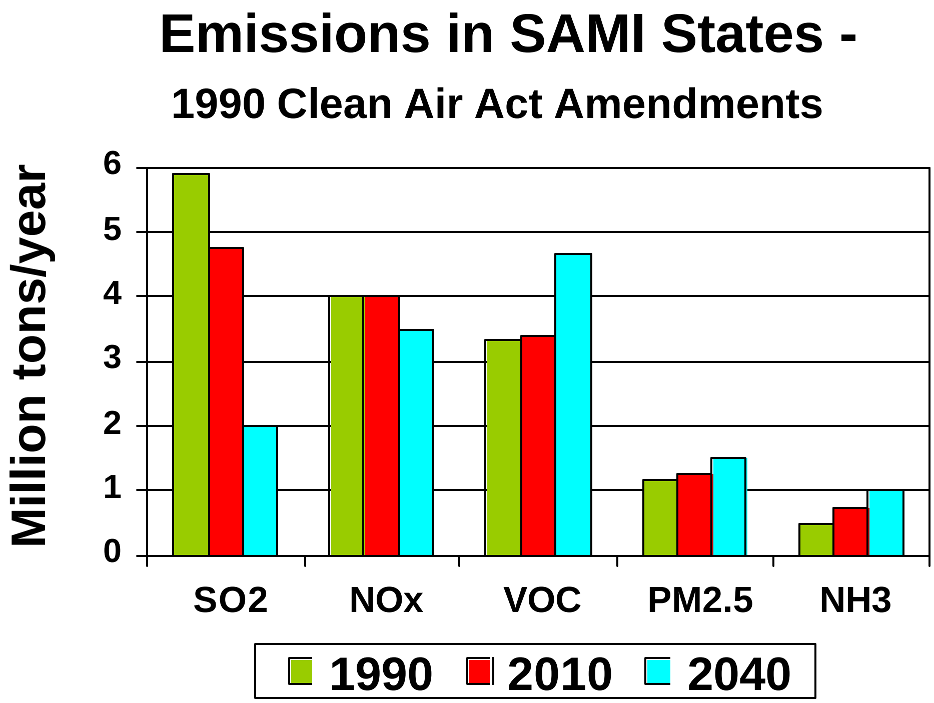

Fig 2-9. Emissions for 1990 and Emission Projections for 2010 and 2040 in the Eight States

Source: SAMI. (2000). Southern Appalachian Mountains Initiative, 2000 Interim Report. http://www.saminet.org

Kentucky, North Carolina, South Carolina, Alabama, West Virginia, and Tennessee) are 680,000 tons per year. The SAMI and 1998 state-level ammonia inventory offered by EPA have similar ammonia emission estimates for the eight states.

The SAMI inventory (SAMI, 2000) results showed that many of the fine particles in the Southern Appalachian Mountains are not emitted directly to the air, rather they are secondary by-products formed in the atmosphere by chemical reactions of primary emissions. For example, SO_2, NOx, and NH_3 emissions combine in the atmosphere to form ammonium sulfate, ammonium bisulfate, sulfuric acid, or ammonium nitrate aerosols. Sulfur aerosols were shown to be the largest contributors to aerosol mass and regional haze in the southeast. Organic compounds were found to be the second largest contributors, with smaller contributions from ammonium nitrate aerosols, elemental carbon (EC) and soil particles.

CHAPTER 3

METHODOLOGY

This chapter presents the methodology for generating ammonia emission inventory for each source category and each sub-source category by county for the year of 1999 for the state of Tennessee. All emissions are estimated based on the annual emissions of NH_3. Total ammonia emissions for the state of Tennessee are estimated by summing over all 54 sub-source categories for all 95 counties in Tennessee.

This chapter provides activity data, emission factors, and total ammonia emission estimates by source. Table 3-1 shows ten source categories and fifty-four sub-source categories used in this study. Based on the literature review and reports by CMU (CMU, 2001), it was determined that the ammonia emission inventory should consist of 10 source categories and 54 sub-source categories as shown in Table 3-1. Emission factor, activity data, and activity data source are tabulated by each sub-source category.

Estimate of ammonia emissions for each sub-source category is provided based on the equation shown below:

$$E = EF \times AL \qquad (3.1)$$

where:

E = Emission Estimates for sub-source categories

EF = Emission Factor for sub-source categories

AL = Activity Level for sub-source categories

Table 3-1. Source Categories and Sub-Source Categories Used in This Study

Source Categories	Sub-Source Categories
Livestock	Cattle&Calves, Milk Cows, Beef Cows, Hog & Pig, Broilers, Layers(>1 year), Layers(<1year), Pullets(<13 weeks), Pullets(>13 weeks), Other Chickens, Horses & Ponies composite, Sheep & Lambs Composite, Goats, Ducks, Geese, Turkeys
Soil	Urban, Forest, Wetland, Agricultural land
Fertilizer	Anhydrous Ammonia, Nitrogen Solutions, Urea, Ammonium Nitrate, Ammonium Sulfate, Ammonium Thiosulfate, Other Straight Nitrogen, Ammonium Phosphates, N-P-K
Mobile Sources	LDGV, LDGT12, LDGT34, HDGV, MC, LDDV, LDDT, HDDV
	NonRoad Gasoline, NonRoad Diesel, Aircraft, Marine Vessels, Railroads
Human Sources	Human Perspiration, Human Respiration, Untreated Human Waste, Cigatette, Household Ammonia Use, Cloth Diapers, Disposal Diapers, Homeless
Biomass Burning	None
Industry	None
POTW	None
Wild Animal	Bear, Deer
Domestic Animal	Dogs, Cats

Note : 10 Source Categories 54 Sub-Source Categories

The unit of emission estimates for each sub-source category used in this study is short tons per year.

This chapter also summarizes the spatial allocation for area sources and temporal allocation for area, mobile, and point sources as these parameters are needed for modeling $PM_{2.5}$ formation for the year 1999.

3.1. METHODOLOGY

3.1.1. Emission Factors

Estimates of ammonia emissions depend on emission factors. In particular, it is believed that ammonia emissions from livestock and fertilizer are significant parts of total NH_3 emissions. Therefore it is important to use the most recent and accurate emission factors for estimating NH_3 emissions.

Recent NH_3 emission factor research in Europe, and specifically in the Netherlands, has focused on increasing the accuracy of NH_3 emission factors for livestock and fertilizer. In 1992, a report on the NH_3 emissions in Europe was published by Asman, 1992. The report incorporated research developed in the Netherlands through around 1990. The emission factors presented by Asman, 1992 are the most recent and accurate emission factors for livestock and fertilizer. In 1994, a final report of development and selection of ammonia emission factors was published by Battye et al., 1994 which included the emission factors.

Emission factors affecting ammonia emissions include: animal age, kind, weight, animal housing system, nitrogen content of feed, manure storage practices, the way of applying the manure or fertilizer, time between spreading and plowing, meteorological conditions, and soil properties. However, data for many of these parameters were not available. For this study, composite emission factors obtained from Battye et al., 1994 for some sub-source categories are chosen to estimate more accurate ammonia emissions from livestock and fertilizer. Emission factors from other sources such as soil, human, and domestic animals were obtained from the Corsi et al., 2000 report.

This chapter presents emission factors used for sub-source categories, a quality rating for the emission factors taken from Battye et al., 1994, and activity levels (population) to estimate ammonia emissions for the year 1999.

3.1.2. Activity Data

Estimates of ammonia emissions also depend on activity data. It is quite hard to collect accurate and detailed activity data by county for each sub-source category. Furthermore, activity data (populations) of livestock classified by weight groups were not available.

Activity data for ducks, geese, turkeys, wild animals, and POTWs (Publicly Owned Treatment Works) were obtained for the years 1996 and 1997. They were not available for the year 1999. Because mink, fox, and rabbit data were not available, they were not included in this study.

This study presents a wide range of information sources, which were used to obtain necessary activity data for 1999.

3.2. LIVESTOCK

Livestock includes the following categories: cattle, hogs and pigs, poultry, horses, sheep, goats, ducks, geese, and turkeys. Sixteen sub-source categories were included in the livestock source category for this study. These sources were estimated to contribute about 57 % of the total ammonia emission inventory in 1999. Fig 3-1 shows a pie chart of total ammonia emissions from the livestock source category. Livestock activity data (population) for Tennessee, emission factors and emissions are presented in Table 3-2.

3.2.1. Cattle

Table 3-3 lists the cattle activities included with their respective Source Classification Codes (SCC) as defined by EPA. Cattle include cattle and calves, beef cows, and milk cows.

3.2.1.1. Cattle and Calves

Cattle and calves include heifers 500 pounds and over, steers 500 pounds and over, bulls 500 pounds and over, and heifers, steers, and bulls under 500 pounds in this study. The emission factor obtained from Battye et al., 1994 for cattle and calves is 22.9 kg NH_3/animal/year. A composite emission factor was used for cattle and calves because the activity data of cattle and calves were not available by weight. The emission factor is assigned a quality rating of B. Activity data for cattle and calves were taken from (TDAS, 2000) for 1999. Ammonia emissions from cattle and calves were calculated by multiplying the emission factor by the activity level (shown in Appendix A, TableA1)

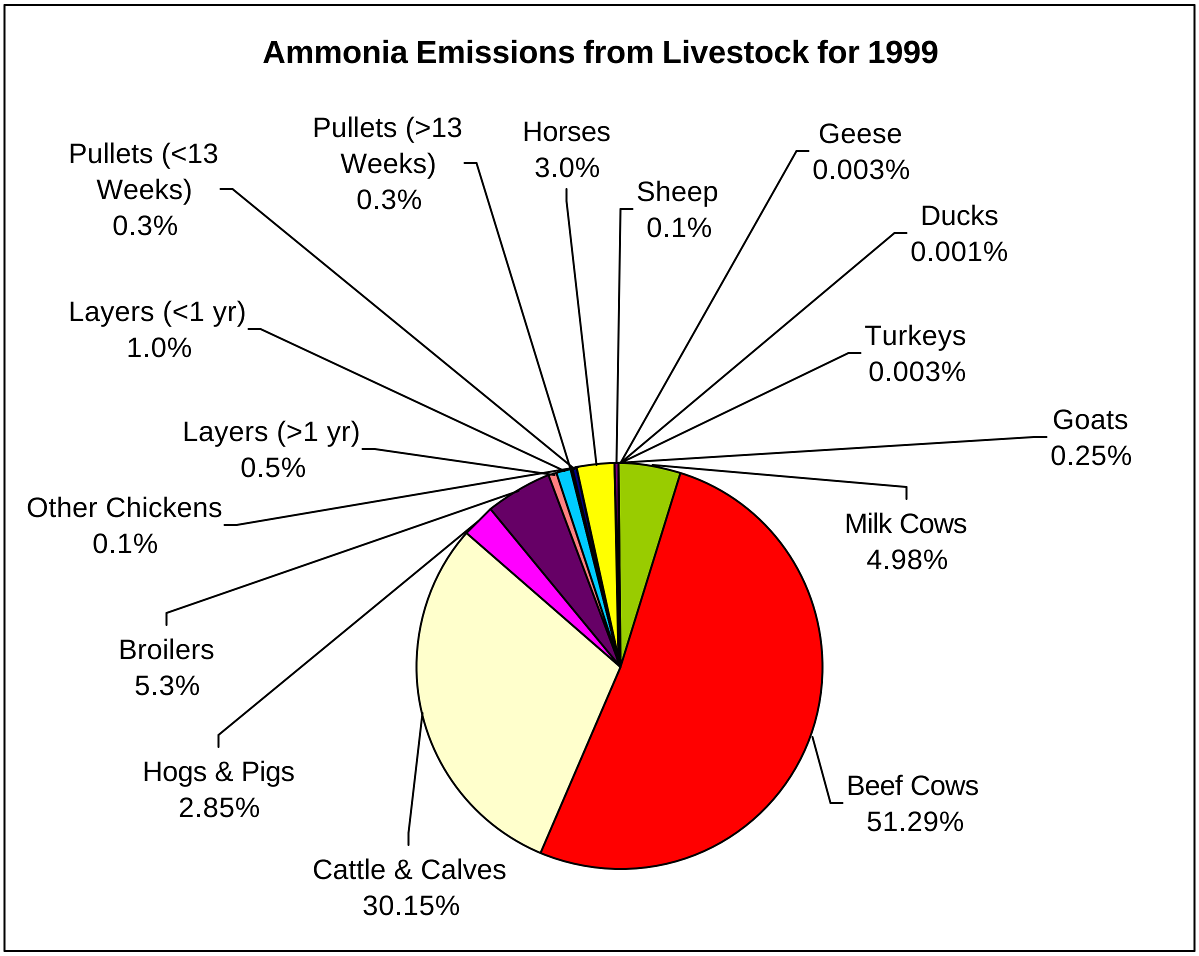

Fig 3-1. A Pie Chart of Total Ammonia Emissions from Livestock Source

Table 3-2. Activity Data, Emission Factors, and Emissions for Livestock

Sub-Source Category	Activity Data (Population)	Emission Factors	Emissions (ton/year)
Milk Cows	100,006	39.72 kgNH3/animal/yr	4,379
Beef Cows	1,030,000	39.72 kgNH3/animal/yr	45,097
Cattle & Calves	1,050,000	22.9 kgNH3/animal/yr	26,505
Hog & Pig	186,134	9.21 kgNH3/animal/yr	2,505
Broilers	25,166,667	0.167 kgNH3/animal/yr	4,633
Layers (>1 yr)	644,738	0.598 kgNH3/animal/yr	425
Layers (<1 yr)	2,527,912	0.305 kgNH3/animal/yr	850
Pullets (>13 Weeks)	985,912	0.269 kgNH3/animal/yr	292
Pullets (<13 Weeks)	1,173,961	0.17 kgNH3/animal/yr	220
Other Chickens	456,690	0.179 kgNH3/animal/yr	90
Horses	85,947	24 kgNH3/animal/yr	2,651
Sheep	10,850	3.37 kgNH3/animal/yr	48
Goats	48,373	3.6 kgNH3/animal/yr	223
Ducks	8,732	0.117 kgNH3/duck/yr	1
Geese	2,257	0.88 kgNH3/geese/yr	3
Turkeys	2,356	0.858 kgNH3/turkey/yr	2
Total			**87,924**

Table 3-3. Activities Including SCCs for Cattle

SCC	Activity
2805020000	Cattle & Calves
2805020000	Beef Cows
2805020000	Milk Cows

for each of the 95 counties in Tennessee. Emissions from cattle and calves were estimated to contribute 30.2% of the total ammonia emissions from livestock source. Cattle and calves were responsible for emitting 26,505 short tons per year.

3.2.1.2. Beef Cows

The emission factor taken Battye et al., 1994 for beef cows is 39.72 kgNH_3/animal/year. The emission factor is assigned a quality rating of B. Activity data for beef cows were obtained from the 2000 Tennessee Department of Agricultural calculated by multiplying the emission factor by the activity level (shown in Appendix A, Table A1) for each of the 95 counties in Tennessee. For example, In the case of Knox County, the number of beef cows estimated from the 2000 Tennessee Agricultural Statistics for the county is 12,200. Thus using equation 3.1, the emissions are 39.72 kg NH_3/animal/year x 12,200 animals = 484,584 kg NH_3/year = 534.16 short tons/year. Emissions from beef cows were estimated to contribute 51.3% of the total ammonia emissions from the livestock source. Beef cows were responsible for emitting 45,097 short tons per year.

3.2.1.3. Milk Cows

The emission factor obtained from Battye et al., 1994 for milk cows is 39.72 kg NH_3/animal/year. A quality rating for the emission factor is B. Activity data (shown in Appendix A1) for milk cows were taken from TDAS, 2000 for 1999. Ammonia emissions from milk cows were calculated in the same way as beef cows. Emissions from milk cows were estimated to contribute 5% of the total ammonia emissions from the livestock source. Milk cows were responsible for emitting 4,379 short tons per year.

3.2.2. Hogs and Pigs

The emission factor obtained from Battye et al., 1994 for hogs and pigs is 9.21 kg NH_3/animal/year. Composite emission factor for hogs and pigs was used because the activity data of hogs and pigs were not available by weight. The quality rating for the emission factor is B. Activity data (shown in Appendix A, Table A1) for hogs and pigs were also taken from TDAS, 2000 for 1999. Ammonia emissions for hogs and pigs were calculated using equation 3.1.

Emissions from hogs and pigs were estimated to contribute 2.85% of the total ammonia emissions from the livestock source. Hogs and pigs were responsible for emitting 2,505 short tons per year. Table 3-4 lists SCC (Source Classification Codes) for hogs and pigs.

3.2.3. Poultry

Table 3-5 lists the activities included with their respective SCCs (Source Classification Codes) as defined by EPA. Poultry are classified into broilers, layers with two subcategories, pullets with two subcategories, and other chickens.

3.2.3.1. Broilers

The emission factor for broilers obtained from Battye et al., 1994 is 0.167 kg NH_3/ animal/year. The quality rating for the emission factor is B. Activity data for

Table 3-4. Activity Including SCCs for Hogs and Pigs

SCC	Activity
2805025000	Hogs and Pigs

Table 3-5. Activity Including SCCs for Poultry

SCC	Activity
2805030000	Broiler
2805030000	Layer(l>yr)
2805030000	Layer(<1yr)
2805030000	Pullet (>13weeks)
2805030000	Pullet(<13weeks)
2805030000	Other Chicken

broilers were obtained from Warren, 2002 that studied the impact of current and proposed CAFO (confined animal feeding operations) regulations on the off-farm market for poultry litter in Tennessee for the year 2000.

According to Warren, 2002, Tennessee was estimated to produce 185,735,282 birds per year. This number represents the total number of birds grown in a year. However, the number of birds on the ground at any one time will be around 31million (six flocks per year with a 12-24 day empty period in the houses between flocks). It takes 38-42 days to grow a flock out to slaughter (depending on finish weight). Therefore, there were around 31 million birds in Tennessee at any one time. This number is a combination of broiler and breeder numbers. About 151 million of the 186 million (or about 81.3%) obtained from TDAS, 2000 were broilers. The rest, approximately 18.7%, were breeders. For example, there were 31,364,782 birds in Bedford County. This number is taken from Warren, 2002 and is the total numbers of birds produced in the county. The number of broilers for the county at any one time is then,

$$(31{,}364{,}782/6) \times (0.813) = 4{,}249{,}928$$

Ammonia emissions from broilers were calculated in the same way as cattle and calves. Emissions from broilers were estimated to contribute 5.3% of the total ammonia emissions from the livestock source category. Broilers were responsible for emitting 4,633 short tons per year.

3.2.3.2. Layers (> 1year)

The emission factor taken from Battye et al., 1994 for layers (>1 year) is 0.598 kg NH_3/animal/year. It is unclear what the difference is between layers (>1 year) and hens. The assumption made in this study is that layers (>1 year) and hens are the same. Therefore, the emission factor for hens obtained from Battye et al., 1994 was used for layers (>1 year) in this study. The quality rating of the emission factor is B. The number of layers (>1year) for each county was calculated in the same way as broilers (shown in Appendix A, Table A1). For example, in the case of layers (>1year) in Bedford County, the calculation is:

$$(31{,}364{,}782/6) \times (0.187) \times (240{,}000/2{,}155{,}000) = 108{,}867$$

The numbers 240,000/2,155,000 were obtained from TDAS, 2000 and were the number of layers (>1yr) divided by total poultry (excluding commercial broilers).

Ammonia emissions from layers (>1year) were calculated in the same way as cattle and calves. Emissions from layers (>1year) were estimated to contribute 0.48% of the total ammonia emissions from the livestock source. Layers (>1year) were responsible for emitting 425 short tons per year.

3.2.3.3. Layers (< 1 year)

The emission factor taken from Battye et al., 1994 for layers (<1year) is 0.305 kg NH_3/animal/year. As mentioned above for layers (>1year), an assumption is needed. The assumption is that layers (< 1year) and pullets of laying age are the same. Therefore, the emissions factor for pullets of laying age obtained from Battye et al., 1994 was used for layers (<1year). The quality rating for the emission factor is B. The number of layers (<1year) for each county in Tennessee was calculated in the same way as layers (>1year) (shown in Appendix A1). For example, in the case of layers (<1year) in Bedford County, the calculation is then:

$$(31{,}364{,}782/6) \times (0.187) \times (941{,}000/2{,}155{,}000) = 426{,}850$$

The numbers 941,000/2,155,000 were obtained from TDAS, 2000 and were the number of layers (<1year) divided by total poultry (excluding commercial broilers). Ammonia emissions for layers (<1year) were calculated in the same way as cattle and calves. Emissions from layers (<1year) were estimated to contribute 0.97 % of the total ammonia emissions from the livestock source. Layers (<1year) were responsible for emitting 850 short tons per year.

3.2.3.4. Pullets (<13 weeks)

The emission factor taken from Battye et al., 1994 is 0.17 kg NH_3/animal/year. Battye et al., 1994 present emission factor of pullets (under 3 month old). Pullets (<13 weeks) were considered as pullets (under 3 month old) in this study. The quality rating for the emission factor is B. The number of pullets (<13weeks) for each county in Tennessee was calculated in the same way as layers. It is shown in Appendix A, Table A1. For example, in the case of pullets (<13 weeks) in Bedford County, the calculation is shown:

$$(31,364,782/6) \times (0.187) \times (437,000/2,155,000) = 198,229$$

The numbers 437,000/2,155,000 were obtained from TDAS, 2000 and were the number of pullets (<13weeks) divided by total poultry (excluding commercial broilers). Ammonia emissions from pullets (<13weeks) were calculated in the same way as cattle and calves. Emissions from pullets (<13weeks) were estimated to contribute 0.25% of the total ammonia emissions from the livestock source. Pullets (<13 weeks) were responsible for emitting 220 short tons per year.

3.2.3.5. Pullets (>13weeks)

The emission factor taken from Battye et al., 1994 is 0.269 kg NH_3/animal/year. Pullets (>13 weeks) also were considered as pullets (3 month old and older not of laying age) obtained from Battye et al., 1994. Therefore, emission factor of pullets (3 month old and older not of laying age) was used for pullets (>13 weeks). The quality rating for the emission factor is C. The number of pullets (>13 weeks) for each county was calculated in the same way as layers (shown in Appendix A, Table A1). For example, in the case of pullets (>13 weeks) in Bedford County, the calculation is then:

$$(31,364,782/6) \times (0.187) \times (367,000/2,155,000) = 166,476$$

The numbers 367,000/2,155,000 were obtained from TDAS, 2000 and were the number of pullets (>13 weeks) divided by total poultry (excluding commercial broilers). Ammonia emissions from pullets (>13 weeks) were also calculated in the same way as pullets (<13weeks). Emissions from pullets (>13 weeks) were estimated to contribute 0.33% of the total ammonia emissions from the livestock source. Pullets (>13 weeks) were responsible for emitting 292 short tons per year.

3.2.3.6. Other Chickens

The emission factor taken from Battye et al., 1994 for other chickens is 0.179 kg NH_3/animal/year. The quality rating for the emission factor is C. The number of other chickens for each county was calculated by the following method (shown in Appendix A, Table A1). For example, in the case of other chickens in Bedford County, the calculation is then:

(31,364,782/6) x (0.187) x (170,000/2,155,000) = 77,120

The numbers 170,000/2,155,000 were obtained from TDAS, 2000 and were the number of other chickens divided by total poultry (excluding commercial broilers). Ammonia emissions from other chickens were also calculated in the same way as cattle and calves. Emissions from other chickens were estimated to contribute 0.25% of the total ammonia emissions from the livestock source. Other chickens were responsible for emitting 220 short tons per year.

3.2.4. Horses

Table 3-6 lists the activity with SCCs (Source Classification Codes) as defined by EPA for horses. The emission factor obtained from Corsi et al., 2000 for horses is 24 kg NH_3/animal/year. The quality rating for the emission factor is D. The number of horses as activity level for each county was obtained from Pechan, 2002 (shown in Appendix A Table A1).

Ammonia emissions from horses were calculated by multiplying the emission factor by the activity level for each of the 95 counties in Tennessee. Ammonia emissions from horses were estimated to contribute 3% of the total ammonia emissions from the livestock. Horses were responsible for emitting 2,651 short tons per year.

3.2.5. Sheep

Table 3-7 lists the activity with SCCs (Source Classification Codes) for sheep. The emission factor taken from Battye et al., 1994 for sheep is 3.37 kg NH_3/animal/year.

Composite sheep and lambs emission factor was used. The quality rating for the emission factor is D. Ammonia emissions from sheep were calculated by multiplying the emission factor by the activity level for each of the 95 counties in Tennessee. The number of sheep as activity level for each county was obtained from Pechan, 2002 (shown in Appendix A, Table A1).

Table 3-6. Activities Including SCCs for Horses

SCC	Activity
2805035000	Horses

Table 3-7. Activities Including SCCs for Sheep

SCC	Activity
2805040000	Sheep

Ammonia emissions from sheep were estimated to contribute 0.05% of the total ammonia emissions from the livestock source. Sheep were responsible for emitting 48 short tons per year.

3.2.6. Goats

Table 3-8 lists the activity with SCCs (Source Classification Codes) for goats. The emission factor taken from Corsi et al., 2000 for goats is 3.6 kg NH_3/animal/year. The quality rating for the emission factor is D.

Ammonia emissions from goats were calculated by multiplying the emission factor by the activity level for each of the 95 counties in Tennessee.

The number of goats as activity level for each county is obtained from Pechan, 2002 (shown in Appendix A Table A1). Ammonia emissions from goats were estimated to contribute 0.25% of the total ammonia emissions from the livestock source. Goats were responsible for emitting 223 short tons per year.

3.2.7. Ducks

Table 3-9 lists the activity with SCCs (Source Classification Codes) for ducks. The emission factor taken from Battye et al., 1994 for ducks is 0.117 kg NH_3/animal/year. The quality rating for the emission factor is B. Ammonia emissions from ducks were

Table 3-8. Activities Including SCCs for Goats

SCC	Activity
2805045001	Goats

Table 3-9. Activities Including SCCs for Ducks

SCC	Activity
2805030000	Ducks

calculated by multiplying the emission factor by the activity level for each of the 95 counties in Tennessee. The number of ducks as activity level for each county was obtained from the 1997 United States Department of Agriculture Economics and Statistics (USDA, 1997) due to no activity data available for 1999. Ammonia emissions from ducks were estimated to contribute 0.0015% of the total ammonia emissions from the livestock source. Ducks were responsible for emitting 1.31 short tons per year.

3.2.8. Geese

Table 3-10 lists the activity with SCCs (Source Classification Codes) defined by EPA for geese. The emission factor obtained from Corsi et al., 2000 for geese is 0.88 kg NH_3/animal/year. The quality rating for the emission factor is D. Ammonia emissions from ducks were calculated by multiplying the emission factor by the activity level for each of the 95 counties in Tennessee. The number of geese as activity level for each county was obtained from USDA, 1997 due to no activity data available for 1999 (shown in Appendix A Table A1). Ammonia emissions from geese were estimated to contribute

Table 3-10. Activities Including SCCs for Geese

SCC	Activity
2805030000	Geese

0.003% of the total ammonia emissions from the livestock source. Ducks were responsible for emitting 3 short tons per year.

3.2.9. Turkeys

Table 3-11 lists the activity with SCCs (Source Classification Codes) for turkeys. The emission factor taken from Battye et al., 1994 for turkeys is 0.858 kg NH_3/animal/year. The quality rating for the emission factor is B. Ammonia emissions from turkeys were calculated by multiplying the emission factor by the activity level for each of the 95 counties in Tennessee. The number of turkeys as activity level for each county was obtained from USDA, 1997 due to no activity data available for 1999 (shown in Appendix A Table A1). Ammonia emissions from turkeys were estimated to contribute 0.0027% of the total ammonia emissions from the livestock source. Turkeys were responsible for emitting 2 short tons per year.

3.3. SOIL

Soil emissions depend on the soil type and include the following four categories: urban land, forestland, wetland, and agricultural land. Vegetation and soil exchange nitrogen with the atmosphere. Some of this nitrogen is exchanged in the form of ammonia. While many researchers have studied the exchange of nitrogen, few studies

Table 3-11. Activities Including SCCs for Turkeys

SCC	Activity
2805030000	Turkeys

have just concentrated on the ammonia exchange. Therefore, there are still many uncertainties in quantifying ammonia emissions from soil. Soil emissions from the above four categories were estimated to contribute 33% of the total ammonia emission inventory for 1999 and were the second largest source of ammonia in this study.

3.3.1. Methodology

Fig 3-2 shows a pie chart of total ammonia emissions from soil sources. Soil activity data for the four categories, emission factors, and emissions are presented in Table 3-12. The activity data of soil sources are shown in Table A2 of Appendix A.

This section presents the methodology about the emission factors and activity levels for urban, forest, and agricultural land soil categories to estimate ammonia emissions by county for the State of Tennessee.

3.3.1.1. Urban Land

The emission factor obtained from Gharib and Cass, 1982 for urban land is 1 kg NH_3/km^2/day. Anderson land use codes used as activity levels for soil emissions were provided by the CMU inventory (CMU, 2001) for the State of Tennessee.

According to Gharib and Cass, 1982, urban soil coverage was assumed to be 44% of the total urban area. The rest of the urban area is covered by structures including

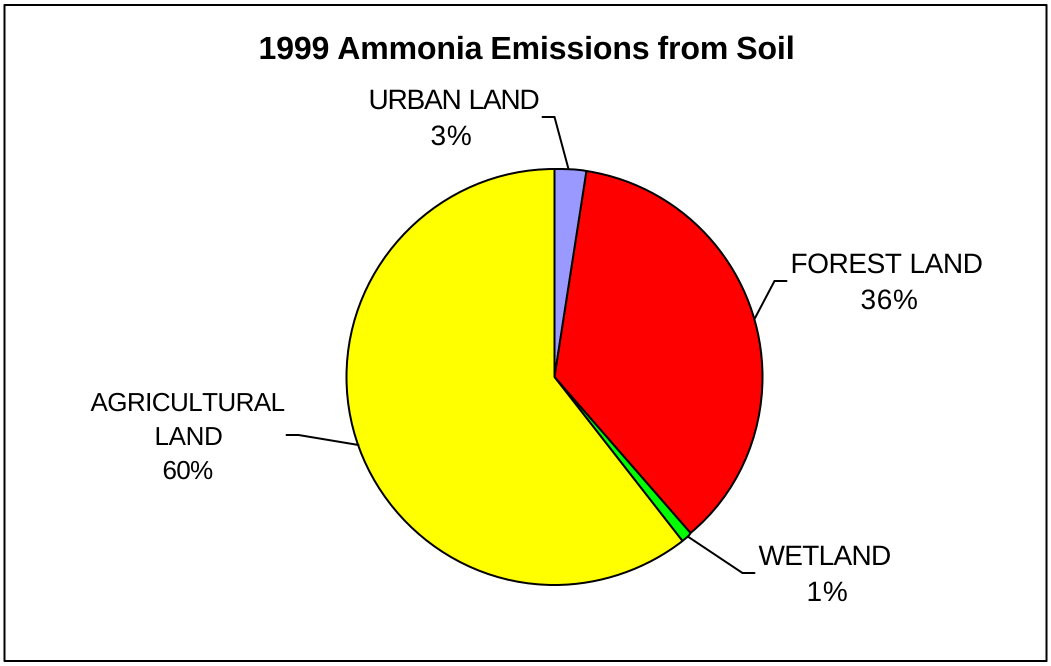

Fig 3-2. A Pie Chart of Ammonia Emissions from Soil

Table 3-12. Activity Data, Emission Factors, and Emissions for Soil

Soil	Activity Data (km^2)	Emission Factor	Total (ton/year)
URBAN LAND	3,949.21	1 kg $NH_3/km^2/day$	1589
FOREST LAND	54,512.97	1 kg $NH_3/km^2/day$	21933
WETLAND	1,204.87	1 kg $NH_3/km^2/day$	485
AGRICULTURAL LAND	43,991.70	2.09 kg $NH_3/km^2/day$	36993
Total			**60,999**

buildings and pavement. Therefore, the formula for activity levels of urban land (shown in Appendix A, Table A2) is as follows.

$$A_{\text{actual urban land}} = 0.44 \text{ x total urban land area}$$

Ammonia emissions from urban land were calculated by multiplying the emission factor by the activity level for each of the 95 counties in Tennessee. Urban lands included barren lands in this study. Ammonia emissions from urban land were estimated to be 3% of the total soil emissions. Urban land was responsible for emitting 1,589 tons per year.

3.3.1.2. Forestland and Wetland

The emission factor taken from Gharib and Cass, 1982 for forestland and wetland is 1 kg $NH_3/km^2/day$. Anderson land use codes (US geological survey developed to support land use/ land cover mapping program) provided in the CMU inventory (CMU, 2001) were used for activity levels of forestland and wetland. Ammonia emissions from forestland and wetland were estimated by multiplying the emission factors by the activity levels county by county. Wetlands and forestlands were estimated to emit 485 tons/year and 21,933 tons/year, respectively. Table 3-13 contains the SCCs and quality ratings of emission factors for sub-source categories of soil.

3.3.1.3. Agricultural Land

Agricultural lands are likely to be croplands, harvested lands, pastured lands and woodlands. The composite emission factor used for agricultural land is 2.09 kg NH_3/km^2/day. This emission factor was calculated based on Bettye, 1988 and Gharib and Cass, 1982. The ratios of croplands, harvested lands, pastured lands and woodlands were obtained from the Bettye, 1988 and the emission factor for each soil pattern was taken from Gharib and Cass, 1982. The emission factors obtained from Gharib and Cass, 1982 for harvested lands, pastured lands, woodlands, and other are 3.7, 1.5, 1, and 1 kg NH_3/km^2/day, respectively. The calculation of the composite emission factor for agricultural land is as follows.

Table 3-13. SCCs with Sub-Source Categories and Emission Factor Ratings

Sub-Source Categories	SCCs	Emission Factor Rating
Urban Land	2701400000	C
Wetland	2701460000	D
Forest	2701480000	C
Agricultural Land	2701420000	D

$$[EF]_{\text{Agricultural Land}} = [(B/A) \times 3.7]_{\text{harvested}} + [(C/A) \times 1.5]_{\text{pastured}} + [(D/A) \times 1]_{\text{other}} + [(E/A) \times 1]_{\text{woodlands}}$$

where :

$[EF]_{\text{Agricultural Land}}$ = Emission Factor for Agricultural Land ($kgNH_3/km^2/day$)

$[(B/A) \times 3.7]_{\text{harvested}}$ = the ratio of harvested land to the total agricultural land in Tennessee x Emission factor for harvested land (3.7 $kgNH_3/km^2/day$)

$[(C/A) \times 1.5]_{\text{pastured}}$ = the ratio of pastured land to the total agricultural land in Tennessee x Emission factor for pastured land (1.5 $kgNH_3/km^2/day$)

$[(D/A) \times 1]_{\text{other}}$ = the ratio of other lands to the total agricultural land in Tennessee x Emission factor for other lands (1 $kgNH_3/km^2/day$)

$[(E/A) \times 1]_{\text{woodlands}}$ = the ratio of woodlands to the total agricultural land in Tennessee x Emission factor for woodlands (1 $kgNH_3/km^2/day$)

The ratio B/A, C/A, D/A, and E/A were obtained from the Tennessee statistical abstract by Battye (page 377), 1988.

That is,

$$\{(4{,}548{,}895/\ 12{,}474{,}931) \times 3.7\} + \{(2{,}608{,}138/\ 12{,}474{,}931) \times 1.5\} + \{(445{,}073/\ 12{,}474{,}931) \times 1\} + \{(3{,}248{,}631/\ 12{,}474{,}931) \times 1\} + \{(17{,}745/\ 12{,}474{,}931) \times 1\} = 2.09$$

Anderson land use codes used as activity levels for agricultural land were provided by the CMU (CMU, 2001) for the State of Tennessee. Emissions from agricultural lands contributed 60% of the total soil emissions as the major source of soil emissions. Agricultural lands were estimated to emit 36,993 tons per year.

3.4. FERTILIZER

Ammonia emissions from fertilizer depend on the specific fertilizer utilized. Furthermore, there is the possibility of double counting emissions with soils because fertilizer application is directly applied on soil. It is assumed here that the emission factors developed by Gharib and Cass, 1982 do not include the direct application of fertilizer. Thus emissions from fertilizer application were estimated and assumed to be directly applied to agricultural land. It is further recommended that these emissions be distributed using the agricultural surrogate.

A final report of 1997 gridded ammonia emission inventory update for the south coast air basin (CA report, 2000) stated that the type of fertilizer, application method, and moisture content of the soil affect ammonia loss from fertilizer. However, for the fertilizer applications categorized in this study, no consideration was given to the application methods and moisture content of the soil since these data were not available. Fertilizers were organized into the 9 sub-source categories: anhydrous ammonia, nitrogen solutions, urea, ammonium nitrate, ammonium sulfate, ammonium thiosulfate, other straight nitrogen, ammonium phosphates, and N-P-K.

3.4.1. Methodology

Fertilizers were estimated to contribute 6% of the total ammonia emissions for the State of Tennessee, accounting for 11,504 tons per year in 1999. It should be noted that the emissions from fertilizer are 11,504 tons per year whereas the emissions from agricultural land in the previous section were 36,993 tons per year, nearly 3.2 times greater. Thus the inclusion of fertilizer as a specific category only increases the emissions from agricultural land by approximately 30%. Emission factors for fertilizers and quality ratings of the emission factors are listed in Table 3-14.

3.4.1.1. Emission Factors and Activity Levels

The emission factors developed by Battye et al., 1994 were used for fertilizers. These 9 sub-source categories presented in this study accounted for the majority of fertilizer use on a county level. The activity data of these sub-source categories are believed to the best source for fertilizer activity data because they were prepared for NEI 99 (EPA's National Emission Inventory for 1999).

Activity levels of the 9 sub-source categories were obtained from Pechan, 2002 and reported as tons/year (shown in Appendix A, Table A3). Estimates of ammonia emissions by county for the State of Tennessee were calculated by multiplying the

Table 3-14. Emission Factors with Sub-Source Categories and Quality Rating of the Emission Factors

Sub-Souce Categories	Emission Factor	Quality Rating	SCC
Anhydrous Ammonia	12kgNH_3/MgN	C	2801700001
Nitrogen Solutions	30kgNH_3/MgN	C	2801700003
Urea	182kgNH_3/MgN	B	2801700004
Ammonium Nitrate	25kgNH_3/MgN	C	2801700005
Ammonium Sulfate	97kgNH_3/MgN	C	2801700006
Ammonium Thiosulfate	30kgNH_3/MgN	C	2801700007
Other Straight Nitrogen	30kgNH_3/MgN	C	2801700008
Ammonium Phosphates	48kgNH_3/MgN	C	2801700009
N-P-K	48kgNH_3/MgN	C	2801700010

emission factor and activity level. For example, to estimate ammonia emissions from anhydrous ammonia in Weakly County, the emission factor and activity level are needed. The emission factor for anhydrous ammonia is 12 kg NH_3/MgN. The activity level is 2,284 tons of nitrogen per year. 1 Mg of nitrogen equals 1000 kg of nitrogen.

Then, (12 kg NH_3/1000 kg N) x (2,284 ton N) = 27,408 tons NH_3/year.

Fig 3-3 shows a pie chart of total ammonia emissions from fertilizers. Ammonia emissions from urea were responsible for 54% of the total ammonia emissions from fertilizers.

3.5. MOBILE SOURCES

Studies of NH_3 emissions from vehicle exhaust date back to the late 1970s. More recent studies have indicated that NH_3 emissions from vehicles may be greater than the current emission inventories indicate, although there is a wide range of estimates for NH_3 emissions rates for mobile sources (Durbin et al., 2001).

Ammonia emissions from mobile source are a result of the combustion process and the emission control systems. Ammonia emissions from gasoline vehicles equipped with catalytic converters are known to be much higher than those of diesel vehicles.

According to the CA report, 2000, mobile sources were the third largest component of the NH_3 emissions inventory in the South Coast Air Basin that surrounds Los Angeles representing approximately 18% of the inventory.

Mobile Sources included onroad mobile sources and nonroad mobile sources in this study. Onroad mobile sources were divided into the 8 sub-source categories: LDGV (Light-Duty Gasoline Vehicles), LDGT1&2 (Light-Duty Gasoline Trucks < 6,000 lbs

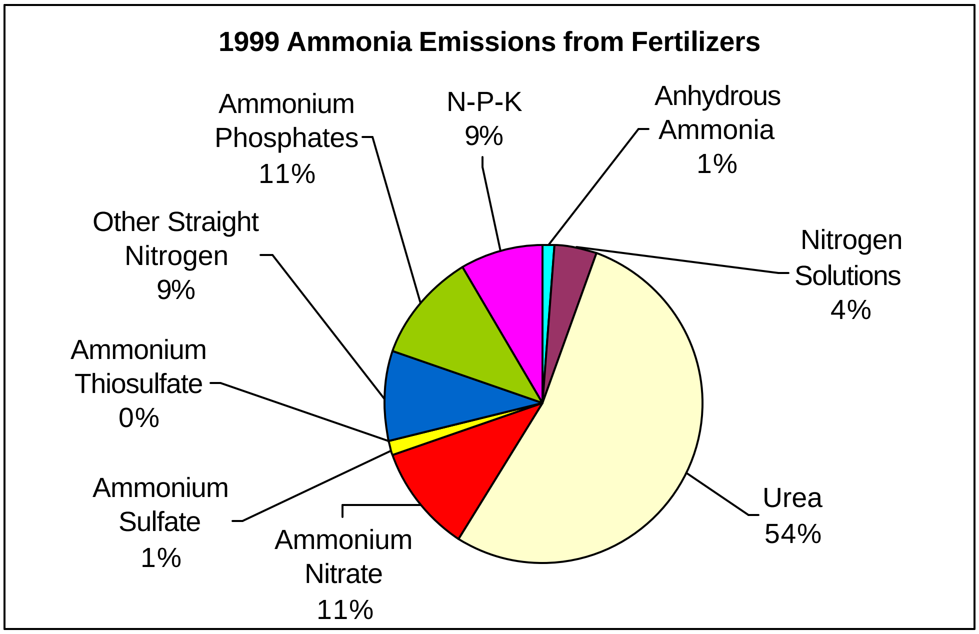

Fig 3-3. A Pie Chart of Ammonia Emissions from Fertilizers

GVW (Gross Vehicle Weight)), LDGT3&4 (Light-Duty Gasoline Trucks 6501 to HDGV (Heavy-Duty Gasoline Vehicles), MC (Motorcycles), LDDV (Light-Duty Diesel Vehicles), LDDT (Light-Duty Diesel Trucks), and HDDV (Heavy-Duty Diesel Vehicles). Nonroad mobile sources were divided into nonroad gasoline, nonroad diesel, aircraft, marine vessels, and railroads. This section presents ammonia emissions from onroad vehicles and nonroad mobile sources.

3.5.1. Methodology

The SCCs with sub-source categories for mobile sources are listed on table 3-15.

Table 3-15. SCCs with Sub-Source Categories for Mobile Sources

Mobile Sources	Sub-Source Categories	SCCs
OnRoad Mobile	LDGV	2201001000
	LDGT1&2	2201020000
	LDGT3&4	2201040000
	HDGV	2201070000
	MC	2201080000
	LDDV	2230001000
	LDDT	2230060000
	HDDV	2230070000
Nonroad Mobile	Nonroad Gasoline	2260000000
	Nonroad Diesel	2270000000
	Aircraft	2275000000
	Marine Vessels	2280000000
	Railroads	2285002000

Ammonia emissions from mobile sources were estimated to contribute 4% of total ammonia emission inventory for this study. Mobile sources were responsible for emitting 6,602 tons per year for the State of Tennessee in 1999. Fig 3-4 shows a pie chart of ammonia emissions from mobile sources. Ammonia emissions from nonroad mobile sources were directly taken from NET99 Tier, 1999 due to the lack of activity data of nonroad mobile sources for the state of Tennessee in 1999. Nonroad mobile sources were estimated to contribute 3% of mobile source emissions as shown in Fig3-4 for nonroad gasoline, nonroad diesel, aircraft, marine vessels, and railroads.

3.5.1.1. Emission Factors and Activity Levels

The emission factors for sub-source categories of onroad mobile sources were obtained from MOBILE 6.1, 2002, which is the most recent EPA emissions factor model.

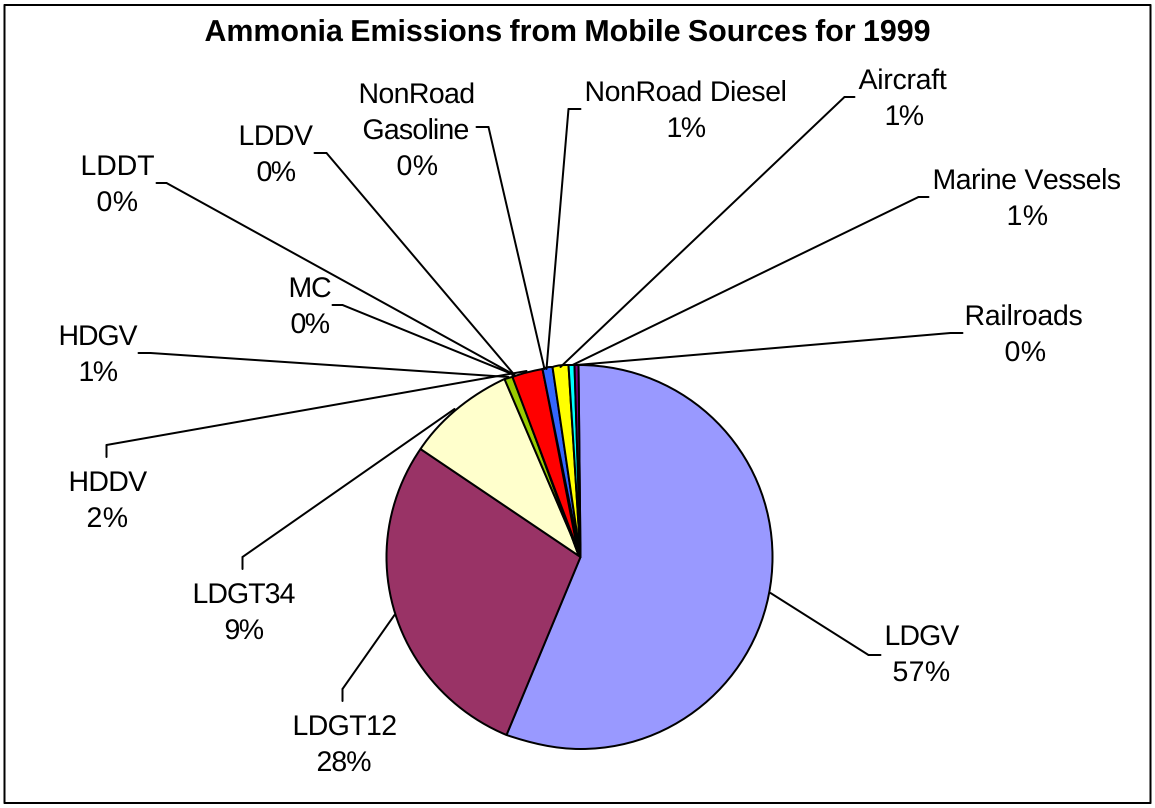

Fig 3-4. Ammonia Emissions from Mobile Sources for 1999

The MOBILE 6.1 draft model calculates a composite, FTP test based gaseous ammonia emission factor for all vehicle types and model years. HDGV (Heavy-Duty Gasoline Vehicles total) and HDDV (Heavy-Duty Diesel Vehicles total) fuel economy values are composites for 8 vehicle categories weighted according to relative VMT (vehicle miles traveled) by each category according to Mobile 6 national defaults. The activity data for onroad mobile sources were obtained from TDOT, 2001 in the form of DVMT (Daily Vehicle Miles Traveled) for each county in Tennessee for 1999.

The county level DVMT data were reported by total vehicles for both urban and rural areas (Tang, 2001). Therefore, it was necessary to classify DVMT of each sub-source category by fraction of vehicles, which was provided by the air research group at the University of Tennessee, Knoxville in order to estimate ammonia emissions from mobile sources on a county level basis for 1999. The activity levels of onroad mobile source by county are shown in Table A4 of Appendix A.

To estimate ammonia emissions for onroad mobile sources by county for the State of Tennessee, the emission factors were multiplied by the daily vehicle miles traveled (DVMT). Because these estimated ammonia emissions are calculated based on the ozone season emissions, annual onroad mobile ammonia emissions by county are calculated by multiplying the ozone season emissions by seasonal adjustment factors associated with each statewide road classification. Table 3-16 presents the seasonal adjustment factors by statewide road classification with SCCs. To provide ammonia emissions in terms of tons per year, it was necessary to multiply the daily emissions by 365. The activity level and the emission factor of each onroad mobile sub-source category are tabulated in Table 3-17. Ammonia emissions from LDGV (Light-Duty gasoline Vehicle total) were

Table 3-16. Seasonal Adjustment Factors with SCCs for Onroad Mobile Sources

SCCs	State Wide Road Classification	Seasonal Adjustment Factors
2201001110	Interstate Rural	0.9124
2201001130 2201001150 2201001170 2201001190 2201001210	Other Rural Roads	0.9733
2201001230 2201001250 2201001270 2201001290 2201001310 2201001330	All Urban	0.9848

Table 3-17. Activity Data and Emission Factors for Onroad Mobile Sources

Onroad mobile sources	Activity Data (Miles/day)	E.F.	Total (ton/yr)
LDGV	95935211	MOBILE 6.1 Draft	3709.62
LTGT12	51179423		1857.49
LTGT34	17317517		615.29
HDGV	3115173		52.58
MC	736977		1.52
LDDV	361250		0.22
LDDT	386211		0.18
HDDV	15067002		155.61
Total			**6392.51**

reported to be 57% of the total mobile emissions as the largest sub-source category for 1999. Ammonia emissions from nonroad mobile sources are shown in Table 3-18.

3.6. HUMAN SOURCES

Table 3-19 lists SCCs with the sub-source categories. Human sources were divided into 8 sub-source categories: human perspiration, human respiration, untreated human waste, cigarette smoking, household ammonia use, cloth diapers, disposable diapers, and homeless. Human sources of ammonia were estimated to contribute 2% of the total ammonia emissions in Tennessee for 1999. Human sources were responsible for emitting 3,018 tons per year.

3.6.1. Methodology

Ammonia emissions from people include human perspiration, human respiration, and untreated human waste. A part of human waste is left untreated such as from the homeless people and portable toilets (CA report, 2000). Treated human waste is included in POTWs (EPA, 2000). Emissions from diapers were divided into cloth diapers and disposable diapers. Disposable diapers are sent to landfills and cloth diapers are

Table 3-18. Ammonia Emissions from Nonroad Mobile Sources

Nonroad Mobile Source	Emissions (tons /year)
Nonroad Gasoline	10
Nonroad Diesel	60
Aircraft	92
Marine Vessels	35
Railroads	13
Total	210

Table3-19. Sub-Source Categories Including SCCs for Human Sources

Sub-Source Category	SCCs
Human Perspiration	281001000
Human Respiration	281001000
Disposable Diapers	2460100000
Cloth Diapers	2460100000
Untreated Human Waste	2460100000
Household ammonia use	2465200000
Homeless	2460100000
Smoking Cigarettes	2810003000

laundered. Ammonia emissions from cigarette smoking are a result of the combustion process (CA report, 2000). Household ammonia emissions are emitted from cleaning solutions and other chemicals used in the home. Fig 3-5 shows a pie chart of ammonia emissions from human sources for 1999 in Tennessee.

3.6.1.1. Emission Factors and Activity Levels

Ammonia emissions from humans were estimated by using several assumptions due to lack of information on emission factors and activity levels. Emission factors for human respiration and perspiration were obtained from the TX report (Corsi et al., 2000), which was reported as averages of the emission factors, found in the published literature. 1999 population estimates for Tennessee at a county level basis were obtained from U.S.Census, 1999 (shown in Appendix A Table A5). The estimated ammonia emissions from human respiration and perspiration by county for the State of Tennessee for the year

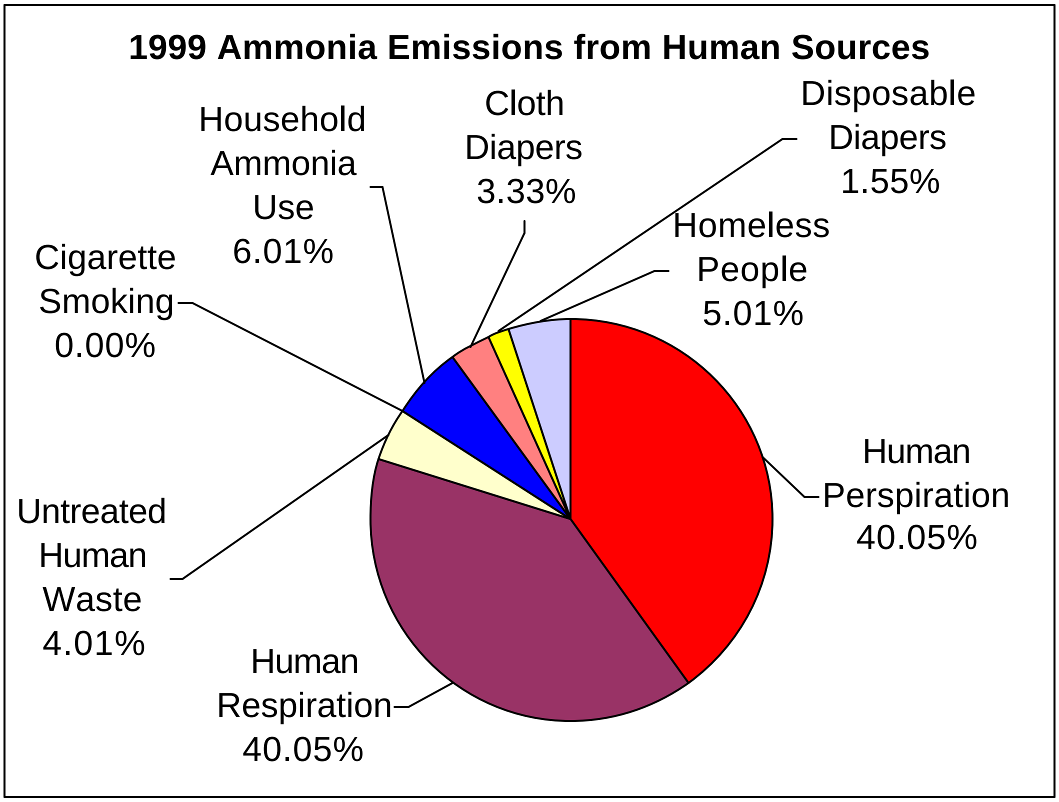

Fig 3-5. Ammonia Emissions from Human Sources for 1999

1999 were calculated by multiplying the emission factor by the human population in each county.

The emission factor for cigarette smoking was taken from Dickson et al., 1991. The unit of the emission factor for cigarette smoking developed from Dickson et al., 1991 is kg NH_3/cigarette. The State Tobacco Activities Tracking and Evaluation (STATE, 1999) indicated that in 1999, approximately 24.9 % of the population over 18 years of age were current smokers and estimated to smoke one or more packs of cigarettes per day. Therefore, 20 cigarettes per day smoked by 24.9 % of the population over 18 years of age were assumed to calculate ammonia emissions from cigarette smoking. The activity data for the population of over 18 years of age by county were obtained from U.S.Census, 1999 for the State of Tennessee for 1999.

The emission factors for cloth diapers and disposable diapers were taken from Dickson et al., 1991. Because this emission factor was only available for diapers, it was used in this emission inventory. To determine the fraction of infants in the population wearing cloth diapers and disposal diapers by county in Tennessee for 1999, the assumption reported by Dickson et al., 1991 was used. The assumption was that 90% of the diapers used were disposable diapers and 10% of the diapers used were cloth diapers. The total percent population of infants under three years old was needed as activity data for infants. The total population of infants under three years old was calculated as the difference between the number of 0-4 years old and 3-4 years old as obtained from the Bureau of Census. The emission factors were then multiplied by the activity data to estimate ammonia emissions from diapers.

The emission factor for homeless people was obtained from Dickson et al., 1991. There was no activity data available for the homeless population. According to Dickson et al., 1991, homeless populations by county were assumed to be 0.5% of the total population. The emission factor was then multiplied by the activity data to estimate ammonia emissions for 1999 by county in Tennessee.

The emission factors for untreated human waste and household ammonia use were taken from Dickson et al., 1991 and Heisler et al., 1988, respectively. These emission factors were used in this inventory since these were the only emission for untreated human waste and household use that were found. Untreated human waste includes the urine excreted from the non-diaper-wearing population other than homeless people, which is not transported to a treatment plant. Ammonia emissions from untreated human waste and household use were estimated by multiplying the emission factors by activity data.

Table 3-20 presents the emission factors, the activity data, and ammonia emission estimates for humans for 1999.

3.7. DOMESTIC ANIMALS

Domestic animals were divided into two sub-source categories: cats and dogs. Ammonia emission estimates from domestic animals were 2% of the total ammonia emission inventory for the State of Tennessee for 1999 for a total of 2,806 tons of ammonia emissions per year. Fig 3-6 shows a pie chart of ammonia emissions from domestic animals for 1999 in Tennessee.

Table 3-20. Emission Factors, Activity Data, and Estimated Ammonia Emissions for Human Sources

Sub-Source Category	Activity Data (population)	Emission Factors	Emissions (ton/year)
Human Perspiration	5483535	0.2 kgNH3/person/yr	1209
Human Respiration	5483535	0.2 kgNH3/person/yr	1209
Untreated Human Waste	5483535	0.02 kg NH3/person/yr	121
Cigarette Smoking	1032256	0.000005 kgNH3/cigarette	0
Household Ammonia Use	5483535	0.03 KgNH3/person/yr	181
Cloth Diapes	29382.4	3.1 kg NH3/infant/yr	100
Disposal Diapers	264441.6	0.16 kg NH3/infant/yr	47
Homeless	27417.675	5 kg NH3/homeless/yr	151
Total			**3,018**

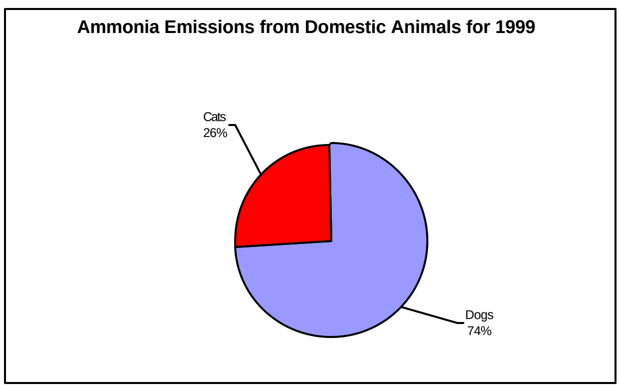

Fig 3-6. Ammonia Emission Inventory for Domestic Animals for 1999

3.7.1. Methodology

Emission factors taken from the TX report (Corsi et al., 2000) and reported to be an average of the emission factors found in the published literature for cats and dogs were used in this inventory. Veterinary Market Statistics (VMS, 1999) provided the basis for the population of domestic animals. The report summarizes that the following formulas can be used to estimate the pet populations.

For dogs: Number of dogs = 0.534 x total number of households

For cats: Number of cats = 0.598 x total number of households

To use the above formulas, the total number of households by county had to be obtained. This was taken from the report (U.S. Census, 1999) which said that in 1996, the U.S. Census Bureau estimated there were 2.65 members per household. The total number of households by county is estimated by dividing total population by 2.65. The total number of dogs and cats by county are summarized in Table A6 of Appendix.

Ammonia emission estimates from domestic animals were calculated by multiplying the emission factor by the activity data obtained from the above formulas for 1999 by county in Tennessee. Emission factors, activity data, and emissions for domestic animals are listed in Table 3-21.

3.8. WILD ANIMALS

Wild animals were divided into black bears and deer for the ammonia emission

Table 3-21. Emission Factors, Activity Data and Emissions for Domestic Animals

Sub-Source Category	SCCs	Activity Data (Population)	Emission Factor	Emissions (tons/year)
Dogs	281001000	1104984.034	2.18 kgNH_3/dog/yr	2655.32
Cats	281001000	1237416.577	0.69 kgNH_3/cat/yr	941.17
Total				3596.49

inventory. Ammonia emissions from wild animals are generated from waste in the same way as livestock. Ammonia emissions from wild animals may be might double counted since soil emissions were estimated separately. However, it is assumed that wastes from wild animals are not included in the soils because of low density of bears and deer population.

3.8.1. Methodology: Activity Data and Emission Factor

Emission factors for wild animals were obtained from Botsford et al., 1997 which was used in CMU inventory (CMU, 2001). Black bears and deer population as activity data (shown in Appendix A7) were taken from CMU inventory (CMU, 2001) due to the fact of that there were no activity data available for wild animals for the year 1999 in Tennessee. Ammonia emissions from wild animals were estimated to contribute 2% of the total ammonia emission inventory for the State of Tennessee. Wild animals were responsible for emitting 3,708 tons per year. Emission factors and activity data are shown on Table 3-22.

3.9. POTWs (Publicly Owned Treatment Works)

Ammonia emissions from household and industrial sources enter the POTW and

Table 3-22. Emission Factors, Activity Data and Emissions for Wild Animals

Sub-Source Category	Activity Data (Population)	Emission Factor	Emissions (ton/year)
BlackBears	1000	4.54 kgNH_3/bear/yr	5.00
Deer	739960	4.54 kg NH_3/deer/yr	3703.12
Total			**3708.13**

are released throughout the wastewater treatment process. Mostly, emissions from POTW sources are emitted from the wastewater and sludge treatment processes. Ammonia emissions from wastewater treatment plants are not included in the TRI (TRI, 1999). POTW emissions are treated as point sources for each facility in the inventory.

3.9.1. Methodology: Activity Data and Emission Factor

POTW flow rates were used for activity data. Activity levels for POTWs obtained from the Environmental Protection Agency's Office of Water (EPA, 2000) were daily average flow rates (shown in Appendix A8). The unit of activity data is 10^6 gallons per day. However, the daily average POTW flow rates were based on the year 1996. Therefore, it was necessary to make an assumption to estimate1999 POTW flow rates by the State of Tennessee. The daily POTW flow rates are assumed to be proportional to the population. The assumption used for 1999 daily POTW flow rates in this study was that it was calculated by multiplying the 1996 daily POTW flow rates and the ratio of 1999 population to 1996 population (1999 population /1996 population) on a county level basis. For example, in the case of POTW flow rates for Anderson County, 1996 daily POTW flow rates were 8.835 MGD (10^6 gal/day) and the ratio of 1999 population to

1996 population is 0.993369. Thus, 8.835 MGD x (0.993369) = 8.776 MGD. This number was then used as the 1999 daily POTW flow rate.

The emission factor for POTWs was obtained from the TX report (Corsi et al., 2000) for which only one emission factor was found in the published literature. To arrive at the total flow rate by county for 1999, the flow estimates in MGD were multiplied by 365 days. Table 3-23 shows the emission factor, activity data, and estimate for POTW source ammonia emissions for 1999 for Tennessee.

Ammonia emissions from POTWs contributed 2% of the total ammonia emissions for 1999 for the State of Tennessee. POTWs were responsible for emitting 2,446 tons per year as a minor source in this study.

3.10. INDUSTRY

Ammonia emissions from industrial sources are produced from various processes. Fugitive ammonia emissions occur during ammonia use in refrigeration, metal heat treating, blueprinting production and water treatment processes (CA report, 2000). Industry plays a small role in the ammonia emission inventory. Industry emissions are also treated as point sources in this inventory.

Emissions for industrial point sources were obtained from the EPA Toxic Release Inventory database (TRI, 1999) which reported actual ammonia emissions based on the year 1999 for industry by county in Tennessee. TRI rules require that ammonia emissions be reported only from facilities with Standard Industrial Classification (SIC) Codes 20 through 39 such as food, paper, petroleum, plastics, fabricated metals, clay,

Table 3-23. Emission Factor, Activity Data, and Estimates for POTWs

Source Category	Activity Data (MGD)	Emission Factor	Estimates (ton/year)
POTW	706.9	8.6 kgNH_3/MG	2446

electrical equipment, and transportation equipment. TRI requires the reporting of estimated data and does not mandate that facilities monitor their releases.

Ammonia emissions from industrial point sources were reported to be 3,136 tons per year and contributed approximately 2% of the total ammonia emissions for 1999 for the State of Tennessee.

3.11. BIOMASS BURNING

Due to the lack of information of activity data for biomass burning, it was obtained directly from the CMU inventory (CMU, 2001). Ammonia emissions from biomass burning were calculated by multiplying the number of acres burned in each county by the typical fuel loading for the region of the county and then, by an emission factor. According to the CMU inventory (CMU, 2001), typical fuel loading amounts were obtained from EPA (Hegg et al., 1998) and activity data for the number of acres burned per county were obtained from the National Interagency Fire Center (EPA, 2000) for 1994 (shown in Appendix A, Table A9). The emission factor was calculated by combining an emission factor for CO from forest fires (EPA, 1998) and a ratio of NH_3/CO. Ammonia emissions from biomass burning were responsible for emitting 202 tons per year in Tennessee.

3.12. SPATIAL ALLOCATION FOR AREA SOURCES

Sources emit ammonia at different locations, referred to as the spatial allocation. For example, fertilizers emit ammonia with the highest concentrations occurring on agricultural land. While point sources can be allocated to exact locations, area sources require the use of spatial surrogates.

Surrogates are assigned to spatially allocate emissions for each SCC (Source Classification Code). Cross reference tables obtained from EPA are then used to match the emission source categories with the corresponding surrogate using these codes. Table 3-24 lists the 20 spatial surrogates which are currently used by EPA for using the CMAQ air quality model.

The source categories for area sources were as follows: Livestock, soil, fertilizer, human, domestic animals, wild animals, and biomass burning. Livestock sources were spatially allocated by agriculture. Emissions from urban land were spatially allocated by urban area. Emissions from forest and wild animals were spatially allocated by forest area. Wetlands were allocated by rural area. Emissions from agricultural lands were spatially allocated by agriculture. Fertilizers were also spatially allocated by agriculture. Human sources were spatially allocated using the population surrogate. Cigarette smoking was allocated to housing. There were no SCCs for domestic and wild animals in the current SCC files offered by EPA. Domestic animals were assigned the same SCC code as human perspiration since they are usually associated with people. Domestic animals were spatially allocated based on total population using 1999 census data. Wild animals were assigned the same SCC code as the horses and ponies composite. Biomass

Table 3-24. Spatial Surrogates Used by EPA

NO.	Description
1	Agriculture
2	Airports
3	Land Area
4	Housing
5	Inverse Housing
6	Inverse Population
7	Major Highways
8	Population
9	Ports
10	Railroads
11	Water Area
12	Rural Area
13	Urban Area
14	Forest Area
15	Urban Primary Roads
16	Rural Primary Roads
17	Urban Secondary Roads
18	Rural Secondary Roads
19	Urban Population
20	Rural Population

burning was spatially allocated by rural population. Table 3-25 provides a summary of the spatial surrogates for area sources.

3.13. TEMPORAL PROFILE

Sources may emit ammonia at different times of the day or year. For example, onroad mobile sources emit the highest ammonia emissions during morning and afternoon rush hours. The distribution of the emissions by time of the year, month, or day is referred to as the temporal allocation. This study includes a summary of temporal profiles by seasonal and diurnal variations.

Table 3-25. The Spatial Surrogates for Area Sources with SCCs

Source Category	1999 NH3 (Sub-Source Categories)	SCC	SSC (Spatial Surrogate Codes)
Livestock	MCOW	2805020000	Agriculture
	BCOW	2805020000	Agriculture
	Cattle & Calves	2805020000	Agriculture
	Hog&Pig	2805025000	Agriculture
	Broiler	2805030000	Agriculture
	Layer(>1yr)	2805030000	Agriculture
	Layer(<1yr)	2805030000	Agriculture
	Pullet (>13weeks)	2805030000	Agriculture
	Pullet(<13weeks)	2805030000	Agriculture
	Other Chicken	2805030000	Agriculture
	Horses	2805035000	Agriculture
	Sheep	2805040000	Agriculture
	Goats	2805045001	Agriculture
	Ducks	2805030000	Agriculture
	Geese	2805030000	Agriculture
	Turkey	2805030000	Agriculture
Soil	Urban Land	2701400000	Urban Area
	Forestland	2701480000	Forest Area
	Wetland	2701460000	Rural Area
	Agricultural Land	2701420000	Agriculture
Fertilizer	Anhydrous Ammonia	2801700001	Agriculture
	Nitrogen Solutions	2801700003	Agriculture
	Urea	2801700004	Agriculture
	Ammonium Nitrate	2801700005	Agriculture
	Ammonium Sulfate	2801700006	Agriculture
	Ammonium Thiosulfate	2801700007	Agriculture
	Other Straight Nitrogen	2801700008	Agriculture
	Ammonium Phosphates	2801700009	Agriculture
	N-P-K	2801700010	Agriculture
Human	Human Perspiration	281001000	Population
	Human Respiration	281001000	Population
	Disposal Diapers	2460100000	Population
	Cloth Diapers	2460100000	Population
	Untreated Human Waste	2460100000	Population
	Household ammonia use	2465200000	Population
	Homeless	2460100000	Population
	Smoking Cigarette	2810003000	Housing
Wild Animal	Deer	2805035000	Forest Area
	Black Bear	2805035000	Forest Area
Domestic Aniaml	Dog	281001000	Population
	Cat	281001000	Population
Biomass Burning		2810015000	Rural Population

Sources are assigned a temporal profile based on the SCCs (Source Classification Codes) and the nature of source emissions. The cross-reference tables obtained from EPA match the emission source categories with the corresponding profile using these SCC codes. Table 3-26 lists the SCCs and temporal profile codes matched with each sub-source category in the cross-reference file. The temporal profile codes list the monthly, weekly, and hourly weighting factors for each source category. The temporal allocation profile and weighting factor files were found on CHIEF's website (Stella, 2002). These factors are be used to estimate monthly, weekly, and hourly emissions from annual emission data. Table 3-27 provides the monthly, weekly, and hourly weighting factors associated with the profile code. The fractions shown in Table 3-28 correspond to the ratio of each weighting factor to the total. Therefore, monthly, weekly, and hourly emissions are calculated by multiplying annual emissions by the weighting ratio for month, week, and hour.

Fig 3-7 shows the monthly, weekly, and hourly temporal plots by source categories. According to the monthly plot, ammonia emissions from livestock such as cattle & calves, beef & milk cows, hogs & pigs, sheep, goats, ducks, geese, and turkeys show seasonal variation because of temperature changes. According to data by Armstrong, 2002, ammonia emissions from poultry appear to have no diurnal variation. Fig 3-8 shows diurnal variation for poultry. This is explained by the fact that the temperature in enclosed building such as poultry houses is controlled by fans and ventilation and is enclosed. It is recommended that a flat profile for poultry be used.

Table 3-26. Sub-Source Categories with SCCs in the Cross Reference Files

AREA SCC	Temporal Profile Codes Monthly	Weekly	Daily	
2805020000	489	7	26	Livestock
2805025000	489	7	26	
2805030000	489	7	26	
2805035000	262	7	26	
2805040000	489	7	26	
2805045001	489	7	26	
2805005000	262	7	26	
2701400000	262	7	26	Soil
2701420000	262	7	26	
2701460000	262	7	26	
2701480000	262	7	26	
2801700001	488	7	26	Fertilizer
2801700003	488	7	26	
2801700004	488	7	26	
2801700005	488	7	26	
2801700006	488	7	26	
2801700007	488	7	26	
2801700008	488	7	26	
2801700009	488	7	26	
2801700010	488	7	26	
2810010000	262	7	24	Human
2460100000	262	7	26	
2465200000	258	7	26	
2810003000	262	7	24	
2805035000	262	7	26	Wild Animals
2810010000	262	7	24	Domestic Animals
2810015000	14	7	24	Biomass Burning
MOBILE	**Monthly**	**Weekly**	**Daily**	
2201001000	262	2002	2013	OnRoad Mobile Sources
2201020000	262	2002	2013	
2201040000	262	2002	2013	
2201070000	262	2002	2013	
2201080000	262	2002	2013	
2230001000	262	2002	2013	
2230060000	262	2002	2013	
2230070000	262	2002	2013	
2260000000	22	7	26	NonRoad Mobile Sources
2270000000	21	7	26	
2275000000	262	7	26	
2280000000	262	7	24	
2285002000	262	7	24	
POINT	**Monthly**	**Weekly**	**Daily**	
2630020000	262	7	26	POTW

Table 3-27. Monthly, Weekly, and Hourly Weighting Factors with SCCs.

AREA SCC	MONTHLY PROFILE CODE	Monthly Temporal Weight												
		Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total
2805020000	489	50	50	83	83	83	133	133	133	67	67	67	50	999
2805020000	489	50	50	83	83	83	133	133	133	67	67	67	50	999
2805025000	489	50	50	83	83	83	133	133	133	67	67	67	50	999
2805030000	489	50	50	83	83	83	133	133	133	67	67	67	50	999
2805035000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2805040000	489	50	50	83	83	83	133	133	133	67	67	67	50	999
2805045001	489	50	50	83	83	83	133	133	133	67	67	67	50	999
2805030000	489	50	50	83	83	83	133	133	133	67	67	67	50	999
2701400000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2701420000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2701460000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2701480000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2801700001	982	20	41	234	231	138	173	24	20	44	30	28	18	1000
2801700003	982	20	41	234	231	138	173	24	20	44	30	28	18	1000
2801700004	982	20	41	234	231	138	173	24	20	44	30	28	18	1000
2801700005	982	20	41	234	231	138	173	24	20	44	30	28	18	1000
2801700006	982	20	41	234	231	138	173	24	20	44	30	28	18	1000
2801700007	982	20	41	234	231	138	173	24	20	44	30	28	18	1000
2801700008	982	20	41	234	231	138	173	24	20	44	30	28	18	1000
2801700009	982	20	41	234	231	138	173	24	20	44	30	28	18	1000
2801700010	982	20	41	234	231	138	173	24	20	44	30	28	18	1000
2810010000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2460100000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2465200000	258	83	83	82	82	82	84	84	84	85	85	85	83	1002
2810003000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2805035000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2810010000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2810015000	14	33	33	233	233	233	0	0	0	67	67	67	33	999
MOBILE SCC	**MONTHLY PROFILE CODE**	**Monthly Temporal Weight**												
		Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total
2201001000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2201020000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2201040000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2201070000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2201080000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2230001000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2230060000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2230070000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2260000000	22	52	52	84	84	84	115	115	115	83	83	83	52	1002
2270000000	21	52	52	83	83	83	115	115	115	83	83	83	52	999
2275000000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2280000000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2285002000	262	83	83	83	83	83	83	83	83	83	83	83	83	996
2285002000	515	70	70	70	70	90	90	90	90	90	90	90	90	1000
POINT SCC	**MONTHLY PROFILE CODE**	**Monthly Temporal Weight**												
		Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total
2630020000	262	83	83	83	83	83	83	83	83	83	83	83	83	996

Table 3-27. Monthly, Weekly, and Hourly weighting Factors with SCCs. (Cont.)

AREA SCC	WEEKLY Profile Code	Weekly Temporal Weight Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total
2805020000	7	143	143	143	143	143	143	143	1000
2805025000	7	143	143	143	143	143	143	143	1000
2805030000	7	143	143	143	143	143	143	143	1000
2805035000	7	143	143	143	143	143	143	143	1000
2805040000	7	143	143	143	143	143	143	143	1000
2805045001	7	143	143	143	143	143	143	143	1000
2805005000	7	143	143	143	143	143	143	143	1000
2701400000	7	143	143	143	143	143	143	143	1000
2701420000	7	143	143	143	143	143	143	143	1000
2701460000	7	143	143	143	143	143	143	143	1000
2701480000	7	143	143	143	143	143	143	143	1000
2801700001	7	143	143	143	143	143	143	143	1000
2801700003	7	143	143	143	143	143	143	143	1000
2801700004	7	143	143	143	143	143	143	143	1000
2801700005	7	143	143	143	143	143	143	143	1000
2801700006	7	143	143	143	143	143	143	143	1000
2801700007	7	143	143	143	143	143	143	143	1000
2801700008	7	143	143	143	143	143	143	143	1000
2801700009	7	143	143	143	143	143	143	143	1000
2801700010	7	143	143	143	143	143	143	143	1000
2810010000	7	143	143	143	143	143	143	143	1000
2460100000	7	143	143	143	143	143	143	143	1000
2465200000	7	143	143	143	143	143	143	143	1000
2810003000	7	143	143	143	143	143	143	143	1000
2805035000	7	143	143	143	143	143	143	143	1000
2810010000	7	143	143	143	143	143	143	143	1000
2810015000	7	143	143	143	143	143	143	143	1000

MOBILE SCC	WEEKLY Profile Code	Weekly Temporal Weight Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total
2201001000	2002	101	100	100	109	111	94	89	704
2201020000	2002	101	100	100	109	111	94	89	704
2201020000	2002	101	100	100	109	111	94	89	704
2201040000	2002	101	100	100	109	111	94	89	704
2201070000	2002	101	100	100	109	111	94	89	704
2201080000	2002	101	100	100	109	111	94	89	704
2230001000	2002	101	100	100	109	111	94	89	704
2230060000	2002	101	100	100	109	111	94	89	704
2230070000	2002	101	100	100	109	111	94	89	704
2260000000	7	143	143	143	143	143	143	143	1000
2270000000	7	143	143	143	143	143	143	143	1000
2275000000	7	143	143	143	143	143	143	143	1000
2280000000	7	143	143	143	143	143	143	143	1000
2285002000	7	143	143	143	143	143	143	143	1000

POINT SCC	WEEKLY Profile Code	Weekly Temporal Weight Mon	Tue	Wed	Thu	Fri	Sat	Sun	Total
2630020000	7	143	143	143	143	143	143	143	1000

Table 3-27. Monthly, Weekly, and Hourly weighting Factors with SCCs.(Cont.)

AREA SCC	Diurnal Profile Code	Hourly Temporal Weight 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
2805020000	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2805025000	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2805030000	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2805035000	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2805040000	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2805045001	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2805005000	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2701400000	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2701420000	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2701460000	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2701480000	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2801700001	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2801700003	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2801700004	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2801700005	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2801700006	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2801700007	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2801700008	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2801700009	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2801700010	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2810010000	24	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	10008
2460100000	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2465200000	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2810003000	24	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	10008
2805035000	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2810010000	24	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	10008
2810015000	24	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	10008
MOBILE	**Diurnal Profile Code**	**Hourly Temporal Weight**																								
SCC	weekday	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
2201001000	2013	86	57	42	39	54	136	350	605	575	525	536	586	633	640	684	757	797	813	615	438	347	290	226	161	9992
2201020000	2013	86	57	42	39	54	136	350	605	575	525	536	586	633	640	684	757	797	813	615	438	347	290	226	161	9992
2201040000	2013	86	57	42	39	54	136	350	605	575	525	536	586	633	640	684	757	797	813	615	438	347	290	226	161	9992
2201070000	2013	86	57	42	39	54	136	350	605	575	525	536	586	633	640	684	757	797	813	615	438	347	290	226	161	9992
2201080000	2013	86	57	42	39	54	136	350	605	575	525	536	586	633	640	684	757	797	813	615	438	347	290	226	161	9992
2230001000	2013	86	57	42	39	54	136	350	605	575	525	536	586	633	640	684	757	797	813	615	438	347	290	226	161	9992
2230060000	2013	86	57	42	39	54	136	350	605	575	525	536	586	633	640	684	757	797	813	615	438	347	290	226	161	9992
2230070000	2013	86	57	42	39	54	136	350	605	575	525	536	586	633	640	684	757	797	813	615	438	347	290	226	161	9992
2260000000	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2270000000	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2275000000	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001
2280000000	24	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	10008
2285002000	24	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	417	10008
weekend	2013	160	98	75	55	52	82	159	234	338	501	609	655	781	771	774	790	789	741	638	503	409	334	261	193	10002
POINT	**Diurnal Profile Code**	**Hourly Temporal Weight**																								
SCC		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
2630020000	26	198	186	182	187	210	250	311	388	467	528	571	604	620	631	635	624	594	548	531	509	425	327	257	218	10001

Table 3-28. Monthly Temporal Fractions by Area, Mobile, and Point Sources

AREA	MONTHLY PROFILE	Fractions												
SCC	CODE	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
2805020000	489	0.05005	0.05005	0.083083	0.083083	0.083083	0.133133	0.133133	0.133133	0.067067	0.067067	0.067067	0.05005	1
2805020000	489	0.05005	0.05005	0.083083	0.083083	0.083083	0.133133	0.133133	0.133133	0.067067	0.067067	0.067067	0.05005	1
2805025000	489	0.05005	0.05005	0.083083	0.083083	0.083083	0.133133	0.133133	0.133133	0.067067	0.067067	0.067067	0.05005	1
2805030000	489	0.05005	0.05005	0.083083	0.083083	0.083083	0.133133	0.133133	0.133133	0.067067	0.067067	0.067067	0.05005	1
2805035000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2805040000	489	0.05005	0.05005	0.083083	0.083083	0.083083	0.133133	0.133133	0.133133	0.067067	0.067067	0.067067	0.05005	1
2805045001	489	0.05005	0.05005	0.083083	0.083083	0.083083	0.133133	0.133133	0.133133	0.067067	0.067067	0.067067	0.05005	1
2805030000	489	0.05005	0.05005	0.083083	0.083083	0.083083	0.133133	0.133133	0.133133	0.067067	0.067067	0.067067	0.05005	1
2701400000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2701420000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2701460000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2701480000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2801700001	982	0.02	0.041	0.234	0.231	0.138	0.173	0.024	0.02	0.044	0.03	0.028	0.018	1
2801700003	982	0.02	0.041	0.234	0.231	0.138	0.173	0.024	0.02	0.044	0.03	0.028	0.018	1
2801700004	982	0.02	0.041	0.234	0.231	0.138	0.173	0.024	0.02	0.044	0.03	0.028	0.018	1
2801700005	982	0.02	0.041	0.234	0.231	0.138	0.173	0.024	0.02	0.044	0.03	0.028	0.018	1
2801700006	982	0.02	0.041	0.234	0.231	0.138	0.173	0.024	0.02	0.044	0.03	0.028	0.018	1
2801700007	982	0.02	0.041	0.234	0.231	0.138	0.173	0.024	0.02	0.044	0.03	0.028	0.018	1
2801700008	982	0.02	0.041	0.234	0.231	0.138	0.173	0.024	0.02	0.044	0.03	0.028	0.018	1
2801700009	982	0.02	0.041	0.234	0.231	0.138	0.173	0.024	0.02	0.044	0.03	0.028	0.018	1
2801700010	982	0.02	0.041	0.234	0.231	0.138	0.173	0.024	0.02	0.044	0.03	0.028	0.018	1
2810010000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2460100000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2465200000	258	0.082834	0.082834	0.081836	0.081836	0.081836	0.083832	0.083832	0.083832	0.08483	0.08483	0.08483	0.082834	
2810003000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2805035000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2810010000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2810015000	14	0.033033	0.033033	0.233233	0.233233	0.233233	0	0	0	0.067067	0.067067	0.067067	0.033033	1
MOBILE	**MONTHLY PROFILE**	**Fractions**												
SCC	**CODE**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
2201001000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2201020000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2201040000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2201070000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2201080000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2230001000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2230060000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2230070000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2260000000	22	0.051896	0.051896	0.083832	0.083832	0.083832	0.11477	0.11477	0.11477	0.082834	0.082834	0.082834	0.051896	1
2270000000	21	0.052052	0.052052	0.083083	0.083083	0.083083	0.115115	0.115115	0.115115	0.083083	0.083083	0.083083	0.052052	1
2275000000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2280000000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2285002000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1
2285002000	515	0.07	0.07	0.07	0.07	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	1
POINT	**MONTHLY PROFILE**	**Fractions**												
SCC	**CODE**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
2630020000	262	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	0.083333	1

Table 3-28. Weekly Temporal Fractions by Area, Mobile, and Point Sources (Cont.)

AREA SCC	WEEKLY PROFILE CODE	Fractions Mon	Tue	Wed	Thur	Fri	Sat	Sun
2805020000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2805025000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2805030000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2805035000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2805040000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2805045001	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2805005000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2701400000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2701420000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2701460000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2701480000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2801700001	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2801700003	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2801700004	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2801700005	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2801700006	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2801700007	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2801700008	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2801700009	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2801700010	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2810010000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2460100000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2465200000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2810003000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2805035000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2810010000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2810015000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
MOBILE SCC	**WEEKLY PROFILE CODE**	**Fractions Mon**	**Tue**	**Wed**	**Thur**	**Fri**	**Sat**	**Sun**
2201001000	2002	0.143466	0.142045	0.142045	0.15483	0.15767	0.133523	0.12642
2201020000	2002	0.143466	0.142045	0.142045	0.15483	0.15767	0.133523	0.12642
2201020000	2002	0.143466	0.142045	0.142045	0.15483	0.15767	0.133523	0.12642
2201040000	2002	0.143466	0.142045	0.142045	0.15483	0.15767	0.133523	0.12642
2201070000	2002	0.143466	0.142045	0.142045	0.15483	0.15767	0.133523	0.12642
2201080000	2002	0.143466	0.142045	0.142045	0.15483	0.15767	0.133523	0.12642
2230001000	2002	0.143466	0.142045	0.142045	0.15483	0.15767	0.133523	0.12642
2230060000	2002	0.143466	0.142045	0.142045	0.15483	0.15767	0.133523	0.12642
2230070000	2002	0.143466	0.142045	0.142045	0.15483	0.15767	0.133523	0.12642
2260000000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2270000000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2275000000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2280000000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
2285002000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143
POINT SCC	**WEEKLY PROFILE CODE**	**Fractions Mon**	**Tue**	**Wed**	**Thur**	**Fri**	**Sat**	**Sun**
2630020000	7	0.143	0.143	0.143	0.143	0.143	0.143	0.143

Table 3-28. Hourly Temporal Fractions by Area, Mobile, and Point Sources (Cont.)

AREA	Diurnal Profile Code	Fractions																							
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
2805020000	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2805025000	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2805030000	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2805035000	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2805040000	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2805045001	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2805005000	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2701400000	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2701420000	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2701460000	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2701480000	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2801700001	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2801700003	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2801700004	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2801700005	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2801700006	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2801700007	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2801700008	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2801700009	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2801700010	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2810010000	24	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	1
2460100000	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2465200000	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2810003000	24	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	1
2805035000	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2810010000	24	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	1
2810015000	24	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	1

MOBILE	Diurnal Profile Code	Fractions																							
SCC	weekday	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
2201001000	2013	0.009	0.006	0.004	0.004	0.005	0.014	0.035	0.061	0.058	0.053	0.054	0.059	0.063	0.064	0.068	0.076	0.080	0.081	0.062	0.044	0.035	0.029	0.023	0.016	1
2201020000	2013	0.009	0.006	0.004	0.004	0.005	0.014	0.035	0.061	0.058	0.053	0.054	0.059	0.063	0.064	0.068	0.076	0.080	0.081	0.062	0.044	0.035	0.029	0.023	0.016	1
2201040000	2013	0.009	0.006	0.004	0.004	0.005	0.014	0.035	0.061	0.058	0.053	0.054	0.059	0.063	0.064	0.068	0.076	0.080	0.081	0.062	0.044	0.035	0.029	0.023	0.016	1
2201070000	2013	0.009	0.006	0.004	0.004	0.005	0.014	0.035	0.061	0.058	0.053	0.054	0.059	0.063	0.064	0.068	0.076	0.080	0.081	0.062	0.044	0.035	0.029	0.023	0.016	1
2201080000	2013	0.009	0.006	0.004	0.004	0.005	0.014	0.035	0.061	0.058	0.053	0.054	0.059	0.063	0.064	0.068	0.076	0.080	0.081	0.062	0.044	0.035	0.029	0.023	0.016	1
2230001000	2013	0.009	0.006	0.004	0.004	0.005	0.014	0.035	0.061	0.058	0.053	0.054	0.059	0.063	0.064	0.068	0.076	0.080	0.081	0.062	0.044	0.035	0.029	0.023	0.016	1
2230060000	2013	0.009	0.006	0.004	0.004	0.005	0.014	0.035	0.061	0.058	0.053	0.054	0.059	0.063	0.064	0.068	0.076	0.080	0.081	0.062	0.044	0.035	0.029	0.023	0.016	1
2230070000	2013	0.009	0.006	0.004	0.004	0.005	0.014	0.035	0.061	0.058	0.053	0.054	0.059	0.063	0.064	0.068	0.076	0.080	0.081	0.062	0.044	0.035	0.029	0.023	0.016	1
2260000000	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2270000000	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2275000000	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1
2280000000	24	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	1
2285002000	24	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	1
weekend	2013	0.016	0.010	0.007	0.005	0.005	0.008	0.016	0.023	0.034	0.050	0.061	0.065	0.078	0.077	0.077	0.079	0.079	0.074	0.064	0.050	0.041	0.033	0.026	0.019	1

POINT	Diurnal Profile Code	Fractions																							
SCC		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
2630020000	26	0.020	0.019	0.018	0.019	0.021	0.025	0.031	0.039	0.047	0.053	0.057	0.060	0.062	0.063	0.063	0.062	0.059	0.055	0.053	0.051	0.042	0.033	0.026	0.022	1

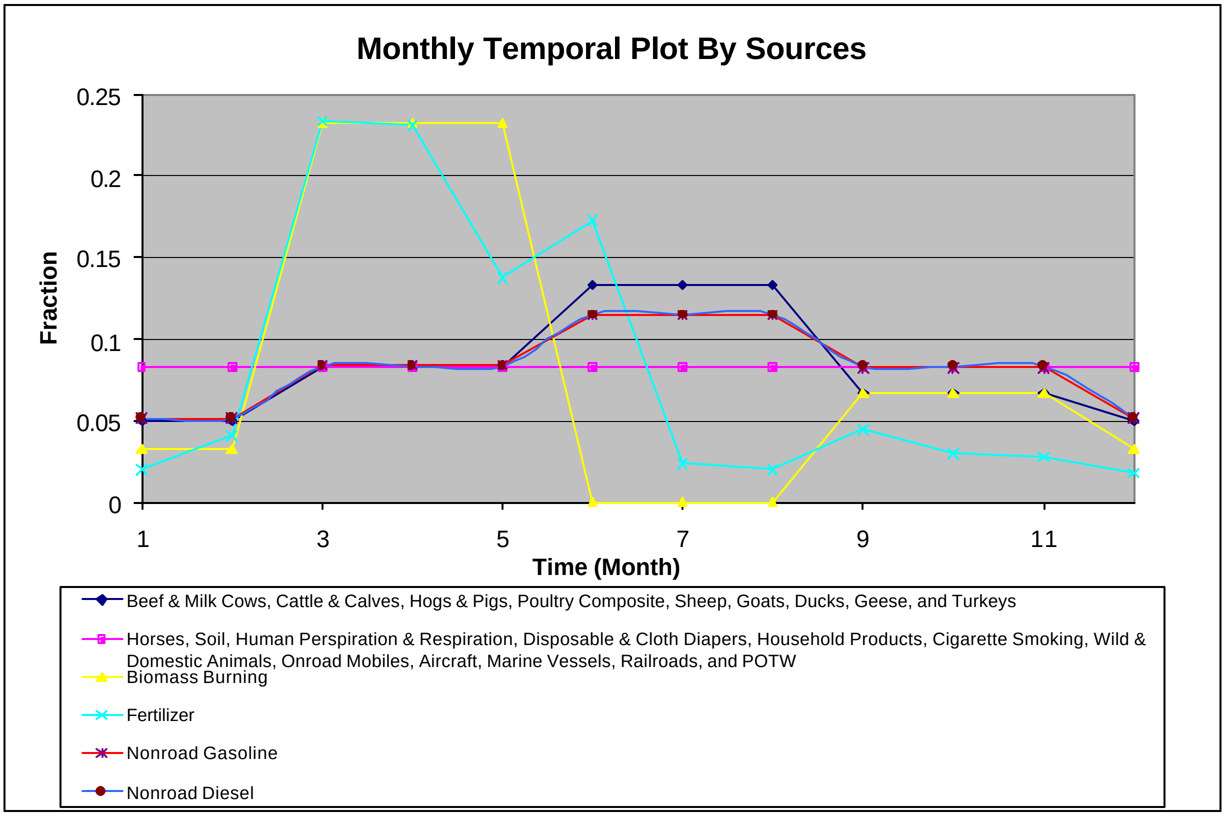

Fig 3-7. Monthly, Weekly, and Hourly Plots by Sources

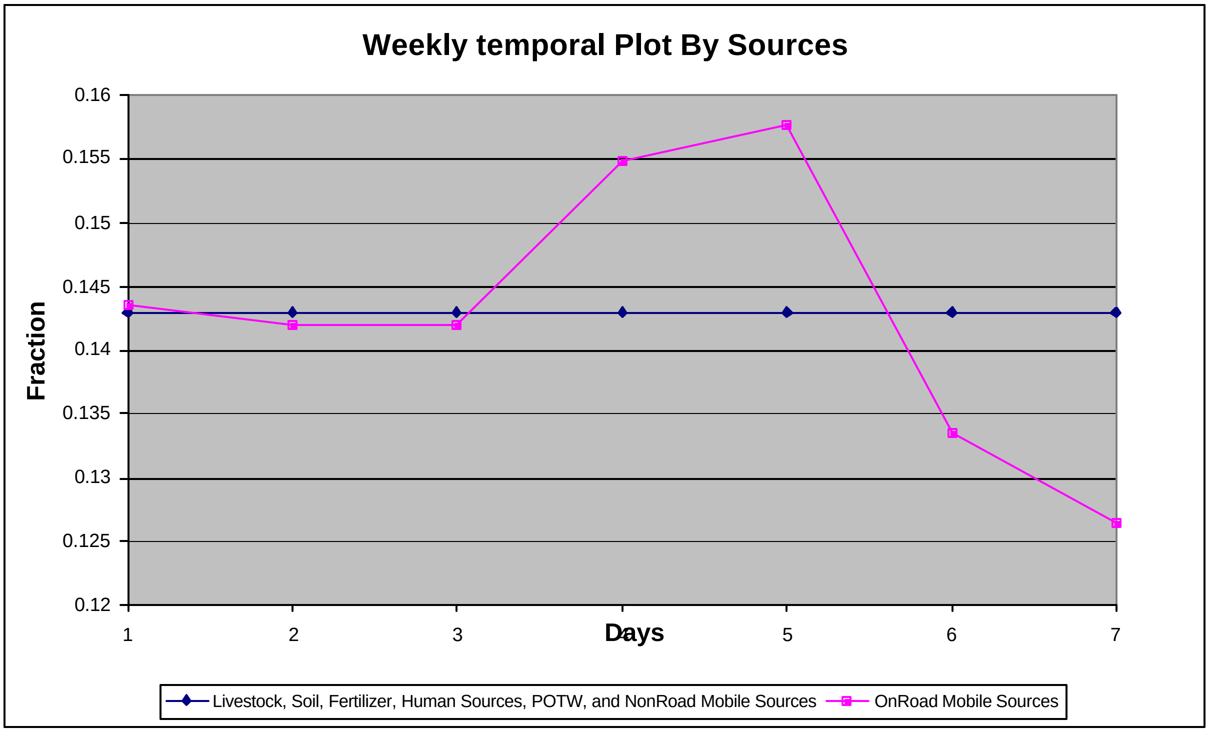

Fig 3-7. Monthly, Weekly, and Hourly Plots by Sources (Cont.)

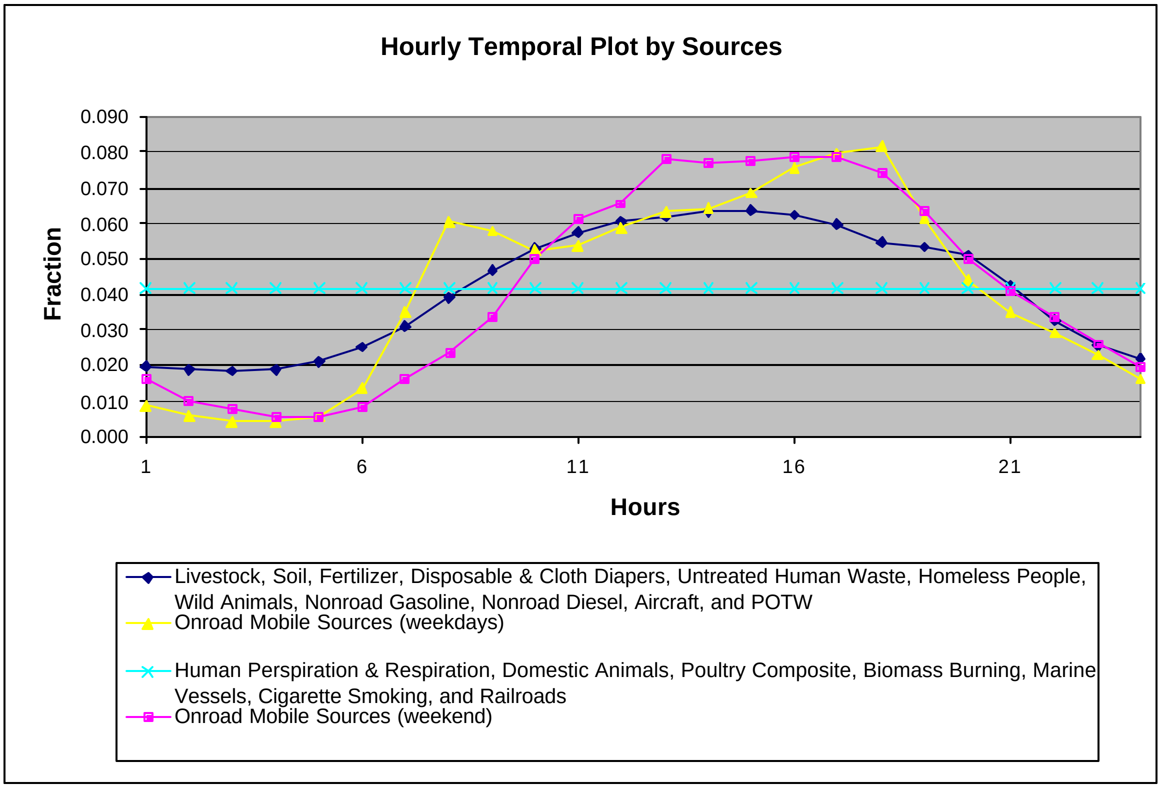

Fig 3-7. Monthly, Weekly, and Hourly Plots by Sources (Cont.)

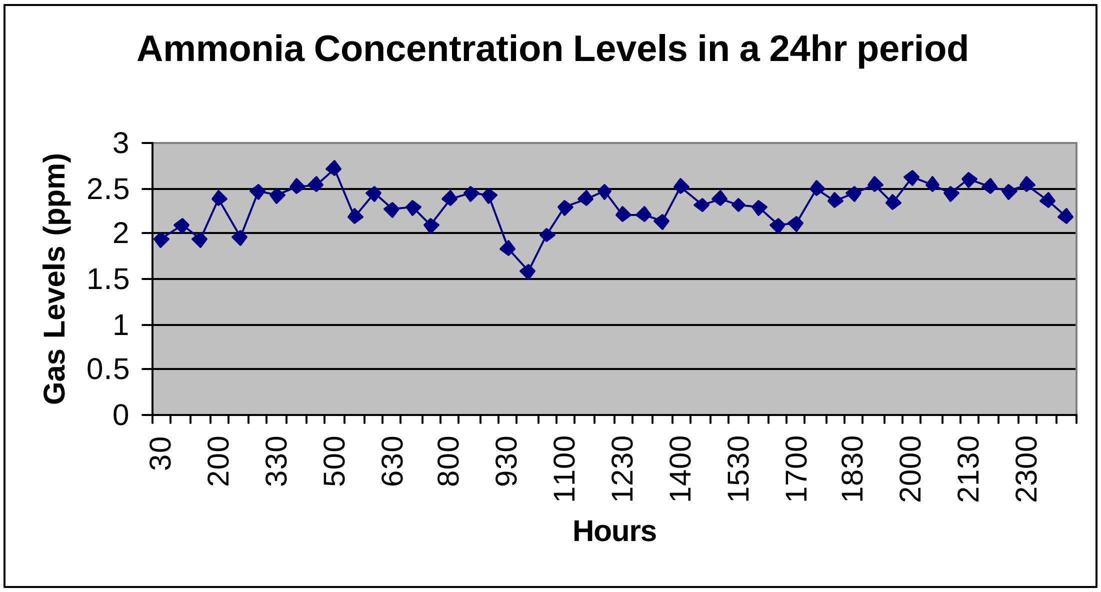

Fig 3-8. Diurnal Variations for Poultry

According to Roberge et al., 2002, temperatures appear to be the most important meteorological parameter controlling ambient NH_3 concentration. Therefore, seasonal activity data and temperature-sensitive emission factors are needed to account for this variation. However, if the seasonal activity data and temperature-sensitive emission factors for livestock are not available, these default fractions could be used to temporally allocate ammonia emission estimates. Fertilizers also show seasonal variation due to their application during the spring season. Because prescribed burning for forest management is mostly applied in the spring and in the fall, biomass burning also shows seasonal variation. On the other hand, human sources, domestic and wild animals, onroad mobile sources, and POTW do not show a seasonal temporal variation. Onroad mobile sources, livestock, soil, and fertilizer also show an hourly temporal variation. Monthly or hourly ammonia emission estimates for agricultural sources may be improved by applying a seasonal or hourly correction factor based on temperature. If seasonal or daily activity data and temperature-sensitive emission factors were available, the ammonia emission estimates would be more accurate. However, these data are not available at the present time. So, the monthly and hourly temporal fractions shown in Table 3-28 may be used to estimate seasonal and daily ammonia emissions.

Very few studies have focused on the temporal profile for seasonal or daily ammonia emissions. Research in this area is still ongoing. The best way to estimate seasonal and diurnal ammonia emissions would be to determine the relationship between ammonia emission factors and environmental factors such as temperature, humidity, and wind speed. This approach of using temporal profiles as stated in this study simply neglects the impact of environmental factors on ammonia emissions. This simple approach is believed to be the best solution for situations with limited data availability.

CHAPTER 4

RESULTS: 1999 AMMONIA EMISSION ESTIMATES FOR TENNESSEE

4.1. SUMMARY OF RESULTS OF STATEWIDE AMMONIA EMISSIONS BY SOURCE

This section summarizes the results of statewide ammonia emission estimates for the year 1999 for the State of Tennessee. Fig 4-1 shows the statewide ammonia emission estimates and percentages for each primary source category and sub-source category. Ammonia emission estimates for sub-source categories are listed in Table 4-1 for each primary source category and sub-source category for 1999.

Livestock was the largest major source, responsible for 48% of the total ammonia emissions, with beef cows accounting for 51.3% of the livestock ammonia emissions. Soils were the second largest major source, accounting for 33% of the total ammonia emissions. Fertilizers were estimated to account for 6% of the total ammonia emissions. Mobile sources were estimated to contribute 4% of the total ammonia emissions, with LDGV (Light- Duty Gasoline Vehicles) accounting for 57% of the mobile emissions. The following categories were each estimated to contribute 2% of the inventory: wild animals, domestic animals, industrial sources according to the TRI (TRI, 1999), and human sources. POTW were estimated to contribute 1% of the inventory. Biomass burning played the smallest role in ammonia emissions, comprising less than 0.1% of the total.

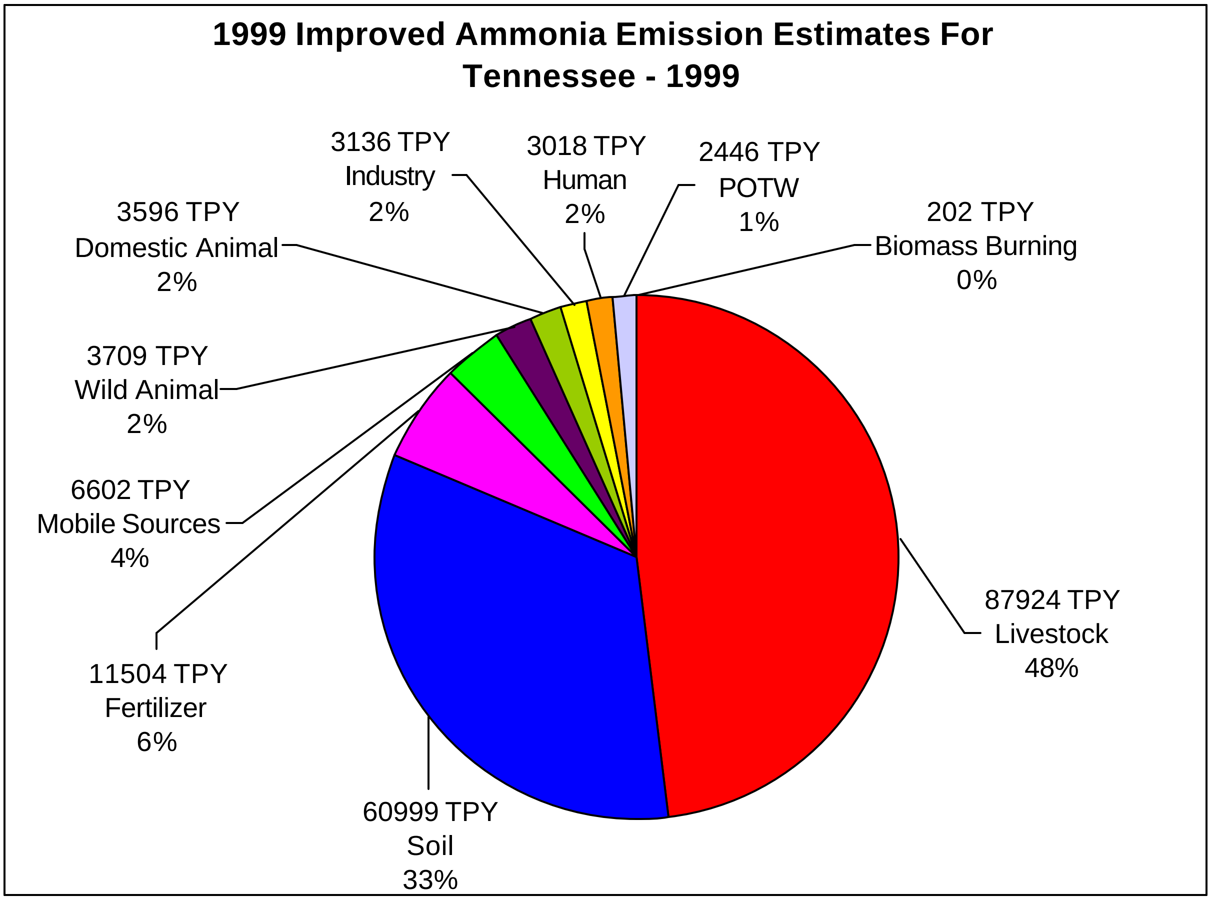

Fig 4-1. Ammonia Emission Estimates and Percentages for Source Categories

Table 4-1. Ammonia Emission Estimates for Sub-Source Categories in Tennessee

Source Category	Sub-Source Category	Emissions (tons/year)
Livestock	Milk Cows	4378.64
	Beef Cows	45097.31
	Cattle & Calves	26505.07
	Hog & Pig	2504.64
	Broilers	4633.00
	Layers (>1 yr)	425.00
	Layers (<1 yr)	849.9
	Pullets (>13 Weeks)	292.34
	Pullets (<13 Weeks)	219.99
	Other Chickens	90.11
	Horses	2650.62
	Sheeps	47.82
	Goats	223.13
	Ducks	1.31
	Geese	2.79
	Turkeys	2.37
	Total	**87924.04**
Soil	Urban land	1588.94
	Forest land	21932.94
	Wetland	484.77
	Agricultural land	36992.53
	Total	**60999.18**
Fertilizer	Anhydrous Ammonia	131.87
	Nitrogen Solutions	508.45
	Urea	6164.18
	Ammonium Nitrate	1257.69
	Ammonium Sulfate	110.68
	Ammonium Thiosulfate	2.43
	Other Straight Nitrogen	1038.76
	Ammonium Phosphates	1290.58
	N-P-K	999.23
	Total	**11503.87**
On-Road Mobile Sources	LDGV	3709.62
	LTGT12	1857.49
	LTGT34	615.29
	HDGV	52.58
	MC	1.52
	LDDV	0.22
	LDDT	0.18
	HDDV	155.61
Nonroad Mobile Sources	Nonroad Gasoline	10.00
	Nonroad Diesel	60.00
	Aircraft	92.00
	Marine Vessels	35.00
	Railroads	13.00
	Total	**6602.51**
Wild Animals	BlackBears	5.00
	Deer	3703.12
	Total	**3708.13**
Domestic Animals	Dogs	2655.32
	Cats	941.17
	Total	**3596.49**
Industry		**3135.69**
Human	Human Perspiration	1208.91
	Human Respiration	1208.91
	Untreated Human Waste	120.89
	Cigarette Smoking	0.006
	Household Ammonia Use	181.34
	Cloth Diapes	100.40
	Disposal Diapers	46.64
	Homeless	151.11
	Total	**3018.22**
Biomass Burning		**202.18**
POTW		**2446**
Total Ammonia Emissions		**183136.12**

4.2. SUMMARY OF RESULTS OF AMMONIA EMISSIONS BY COUNTY BY SOURCE

The total estimated ammonia emissions by source category for each of the 95 counties in Tennessee are listed in Table 4-2. Figs 4-2 to 4-12 show the ammonia emission distributions by county by source category. Twelve counties-- Bedford, Franklin, Giles, Greene, Lawrence, Lincoln, Marion, Robertson, Rutherford, Shelby, Williamson, and Wilson-- each had over 3,100 tons of total ammonia emissions. Their respective total ammonia emissions are listed in Table 4-3. Ammonia emissions from these 12 counties represented more than 25% of the total ammonia emissions for the State of Tennessee. These counties, except for Shelby and Greene, are located in middle Tennessee. Livestock dominated as a major source of ammonia for 10 of these counties. However, Shelby is dominated by emissions from industrial sources. Fig 4-13 shows ammonia emissions from these 12 counties by bar graph.

Tennessee's ninety-five counties had estimated ammonia emissions ranging from 369 to 7,098 tons in 1999. Most of the thirty-two counties having over 1,800 tons of ammonia emissions are located in the middle and east Tennessee areas.

Table 4-4 gives the top ten sub-source categories of ammonia emissions in Tennessee for 1999.

4.3. DISCUSSION OF RESULTS

Shelby County ammonia emissions were the largest in Tennessee for the year 1999, followed by several urban counties such as Davidson, Knox, and Hamilton. Table

Table 4-2. Ammonia Emissions by County

County_name	Soil	Livestock	Mobile	Fertilizer	Industry	Wild Animal	POTW	Domestic Animal	Human	Biomass Burning	NH3 Total (ton/yr)
Anderson	379.33	346.18	84.19	13.76	6.13	40.77	30.37	46.57	38.88	2.39	**988.57**
Bedford	867.27	3106.83	34.79	59.55	17.87	19.37	7.45	22.89	19.22	2.37	**4157.61**
Benton	494.07	376.82	26.23	43.12	0.00	49.23	0.99	10.82	9.00	2.66	**1012.95**
Bledsoe	553.84	920.43	8.42	122.99	0.00	48.77	1.85	7.18	5.99	2.65	**1672.10**
Blount	768.92	1165.96	98.92	160.36	0.00	56.52	22.72	67.41	56.32	1.51	**2398.64**
Bradley	461.79	1993.38	94.90	288.79	82.08	29.49	31.09	55.18	46.11	1.24	**3084.05**
Campbell	536.43	285.48	62.69	4.63	0.00	69.09	6.83	25.23	21.11	0.86	**1012.36**
Cannon	396.47	812.23	10.84	0.10	0.00	21.99	1.26	8.03	6.71	2.04	**1259.67**
Carroll	961.01	689.21	29.40	154.83	0.00	44.76	6.03	19.32	16.13	1.47	**1922.15**
Carter	429.75	348.11	43.90	12.90	0.00	47.10	5.72	34.96	29.09	2.57	**954.10**
Cheatham	392.64	435.00	41.25	3.98	0.00	33.37	2.64	23.70	20.04	1.04	**953.65**
Chester	435.42	323.39	13.96	24.11	0.00	28.30	1.29	9.75	8.15	2.19	**846.57**
Claiborne	655.54	1291.11	29.35	183.88	0.00	46.00	3.46	19.51	16.30	2.38	**2247.53**
Clay	326.82	795.56	6.32	3.80	0.00	26.40	0.76	4.77	3.96	2.36	**1170.75**
Cocke	608.79	721.83	40.97	65.94	0.00	52.94	8.28	21.18	17.64	2.37	**1539.94**
Coffee	665.22	1130.29	72.47	295.46	0.00	29.30	19.98	30.40	25.53	2.09	**2270.74**
Crockett	535.13	271.42	16.70	210.57	2.70	3.41	2.59	9.23	7.70	1.53	**1060.98**
Cumberland	834.34	787.49	74.61	183.23	0.00	89.91	11.10	29.73	24.77	1.73	**2036.92**
Davidson	501.95	378.68	790.72	45.34	0.02	34.78	527.55	347.64	292.33	0.93	**2919.95**
Decatur	457.98	881.87	18.30	123.17	0.00	40.71	1.59	10.61	8.86	2.67	**1545.76**
De Kalb	449.55	520.27	14.78	132.64	0.00	29.75	3.54	7.08	5.87	2.72	**1166.19**
Dickson	680.62	1007.37	53.77	156.36	0.00	51.22	4.56	28.21	23.79	2.81	**2008.72**
Dyer	1003.20	426.70	42.84	86.24	0.60	12.60	16.28	24.09	20.20	0.57	**1633.31**
Fayette	1242.62	1112.45	51.94	86.94	10.88	40.65	6.41	20.62	17.38	1.47	**2591.35**
Fentress	606.76	1061.92	14.39	28.80	0.00	67.27	2.23	10.73	8.95	1.57	**1802.63**
Franklin	809.32	1738.99	31.81	466.25	0.00	49.13	5.30	24.81	20.69	1.15	**3147.44**
Gibson	1208.32	766.96	43.69	569.71	0.00	10.10	17.29	31.50	26.29	1.50	**2675.35**
Giles	1053.13	2335.74	41.15	68.86	0.00	42.74	7.13	19.04	15.96	1.45	**3585.21**
Grainger	448.38	916.45	22.98	76.80	0.00	25.16	0.29	13.26	11.07	2.97	**1517.37**
Greene	1080.67	2962.52	80.87	193.22	0.15	34.78	12.11	39.94	33.22	2.54	**4440.02**
Grundy	429.34	747.53	16.76	68.82	0.00	52.31	0.67	9.21	7.70	0.99	**1333.32**
Hamblen	267.11	740.58	58.64	87.01	0.50	6.78	9.94	35.55	29.68	2.49	**1238.28**
Hamilton	599.91	607.01	360.48	25.34	43.31	55.85	218.16	193.30	161.84	2.04	**2267.25**
Hancock	307.89	524.63	3.80	14.97	0.00	24.80	0.48	4.44	3.71	2.74	**887.45**
Hardeman	941.93	638.13	26.62	111.15	0.00	67.69	4.21	16.04	13.49	0.84	**1820.09**
Hardin	813.18	449.69	25.85	27.83	70.31	63.96	6.32	16.56	13.84	2.34	**1489.88**
Hawkins	705.22	1356.97	41.94	99.86	0.00	45.88	5.96	32.87	27.40	1.94	**2318.04**
Haywood	1026.22	253.25	42.78	202.80	0.00	19.17	3.82	12.73	10.70	1.64	**1573.11**

Table 4-2. Ammonia Emissions by County (Cont.)

County_name	Soil	Livestock	Mobile	Fertilizer	Industry	Wild Animal	POTW	Domestic Animal	Human	Biomass Burning	NH3 Total (ton/yr)
Henderson	767.04	1008.15	55.15	118.42	0.00	51.72	9.79	16.24	13.57	0.96	**2041.04**
Henry	909.04	1172.12	32.33	179.80	0.00	34.17	8.94	19.74	16.43	2.67	**2375.23**
Hickman	798.20	982.47	32.65	98.23	0.00	80.25	1.36	13.96	11.69	2.91	**2021.72**
Houston	243.83	378.55	5.15	13.24	0.00	26.18	0.39	5.17	4.31	2.53	**679.35**
Humphreys	662.78	661.04	30.84	88.75	207.69	67.86	5.91	11.28	9.40	2.52	**1748.05**
Jackson	408.60	502.11	10.34	0.07	0.00	37.22	0.85	6.32	5.25	1.51	**972.28**
Jefferson	490.16	1358.91	75.57	132.80	0.00	15.73	4.17	29.58	24.58	2.18	**2133.68**
Johnson	412.74	340.06	13.93	9.87	0.00	36.46	4.94	10.98	9.11	3.28	**841.36**
Knox	664.45	966.40	446.71	119.55	5.79	31.74	218.37	246.63	206.48	2.90	**2909.02**
Lake	326.21	42.17	5.01	168.93	0.00	2.68	2.02	5.33	4.40	1.59	**558.35**
Lauderdale	838.35	346.42	25.53	282.36	0.00	26.20	5.03	15.89	13.35	2.94	**1556.07**
Lawrence	995.40	2002.77	32.83	154.89	0.00	50.65	7.16	25.99	21.89	1.83	**3293.41**
Lewis	335.13	240.10	7.14	1.95	0.00	40.73	2.81	7.30	6.12	1.88	**643.15**
Lincoln	1014.87	2682.80	29.72	224.27	0.10	31.13	7.51	19.53	16.35	2.79	**4029.06**
Loudon	377.07	1026.26	68.50	2.91	0.00	14.21	24.46	26.16	21.85	2.91	**1564.33**
McMinn	636.41	1151.34	72.78	512.17	106.59	36.97	17.33	12.16	10.21	2.97	**2558.92**
McNairy	787.81	535.84	28.99	39.49	0.00	62.01	5.66	56.90	47.91	1.24	**1565.85**
Macon	488.08	565.76	13.96	283.16	0.00	25.92	2.91	17.65	14.77	1.22	**1413.42**
Madison	935.62	1645.94	126.21	80.31	3.05	34.51	35.96	17.33	14.49	2.40	**2895.82**
Marion	594.58	2265.21	63.40	59.58	0.00	72.70	2.90	46.20	38.82	1.20	**3144.60**
Marshall	627.84	1666.53	33.60	69.86	0.00	22.00	9.23	30.43	25.40	2.73	**2487.62**
Maury	1017.95	508.73	85.98	87.50	26.30	39.11	17.90	15.95	13.29	2.14	**1814.85**
Meigs	274.82	424.60	9.31	0.09	0.00	21.53	0.45	6.65	5.53	1.69	**744.67**
Monroe	831.86	1122.42	39.49	182.53	0.00	81.80	8.80	23.33	19.55	2.93	**2312.73**
Montgomery	823.25	1129.19	113.46	180.77	0.00	39.11	29.87	84.88	72.52	1.98	**2475.03**
Moore	214.38	612.96	5.12	0.17	0.00	8.63	1.11	3.37	2.81	1.63	**850.17**
Morgan	579.92	403.32	13.39	4.56	0.00	77.83	1.36	12.26	10.24	1.21	**1104.08**
Obion	1039.31	823.42	37.87	420.04	4.50	12.93	12.34	21.15	17.61	2.50	**2391.68**
Overton	611.69	1125.41	21.11	78.40	0.00	45.11	5.76	12.89	10.73	2.61	**1913.72**
Perry	487.75	235.88	7.99	37.64	0.00	58.74	1.63	4.96	4.16	2.70	**841.46**
Pickett	223.25	500.91	5.19	1.22	0.00	20.06	1.02	3.09	2.58	1.95	**759.29**
Polk	504.61	623.41	18.44	3.14	0.00	65.36	1.45	9.90	8.23	1.03	**1235.57**
Putnam	558.48	921.40	87.92	253.32	6.83	35.15	26.42	39.18	32.74	1.76	**1963.19**
Rhea	421.48	403.37	25.94	0.71	0.00	35.96	6.36	18.44	15.41	2.05	**929.72**
Roane	429.53	447.07	69.01	30.90	1.49	43.16	13.13	32.80	27.31	2.28	**1096.69**
Robertson	946.58	1775.09	79.87	448.39	0.00	11.76	15.60	35.98	30.38	3.18	**3346.84**
Rutherford	1000.55	1653.07	207.82	539.59	0.08	34.49	39.63	112.42	95.07	1.36	**3684.08**

Table 4-2. Ammonia Emissions by County (Cont.)

County_name	Soil	Livestock	Mobile	Fertilizer	Industry	Wild Animal	POTW	Domestic Animal	Human	Biomass Burning	NH3 Total (ton/yr)
Scott	577.98	244.99	17.38	31.25	0.00	84.63	2.85	13.27	11.17	2.06	**985.58**
Sequatchie	323.99	248.98	12.61	41.18	0.00	37.29	2.83	7.11	5.95	2.12	**682.07**
Sevier	774.94	762.72	87.21	74.49	0.00	75.80	24.69	43.15	36.01	1.38	**1880.40**
Shelby	1093.13	426.46	984.15	377.57	2471.02	32.69	655.04	572.58	483.97	1.28	**7097.89**
Smith	483.59	1202.93	37.34	100.16	0.00	22.29	2.10	11.00	9.24	1.75	**1870.41**
Stewart	542.84	343.28	11.94	1.10	0.00	66.62	0.55	7.71	6.39	3.53	**983.97**
Sullivan	572.28	1030.93	163.86	25.07	67.69	32.92	74.17	98.53	82.03	3.79	**2151.28**
Sumner	890.19	1699.26	128.67	41.06	0.00	28.03	11.42	82.65	69.45	2.85	**2953.58**
Tipton	818.32	371.33	38.26	407.60	0.00	15.16	7.34	31.71	26.92	3.01	**1719.64**
Trousdale	192.59	465.96	7.78	0.17	0.00	7.54	1.05	4.57	3.81	3.01	**686.50**
Unicoi	220.85	69.17	17.04	2.47	0.00	30.71	5.20	11.35	9.42	3.21	**369.43**
Union	308.51	402.29	12.30	81.55	0.00	23.54	1.29	10.88	9.14	2.84	**852.34**
Van Buren	298.51	283.33	5.76	0.46	0.00	36.87	0.00	3.28	2.75	0.62	**631.58**
Warren	756.52	1399.79	35.59	74.29	0.00	26.78	10.74	23.89	19.99	3.35	**2350.95**
Washington	568.36	1963.74	99.10	197.68	0.00	13.35	30.65	67.43	56.21	2.67	**2999.19**
Wayne	897.05	917.11	14.68	88.09	0.00	104.06	2.76	10.76	8.98	2.79	**2046.27**
Weakley	1069.63	1316.62	29.09	288.93	0.00	14.78	5.98	21.61	18.02	2.72	**2767.38**
White	583.15	1434.75	20.71	126.73	0.00	32.63	2.68	15.00	12.53	1.60	**2229.76**
Williamson	910.54	1873.32	144.20	35.37	0.00	40.76	11.07	81.19	68.32	2.52	**3167.29**
Wilson	900.43	1987.30	122.54	94.99	0.00	37.86	14.83	56.73	47.73	2.11	**3264.51**
Total	60999.18	87923.87	6602.49	11503.87	3135.69	3708.13	2446.00	3596.49	3018.22	202.18	**183136.12**

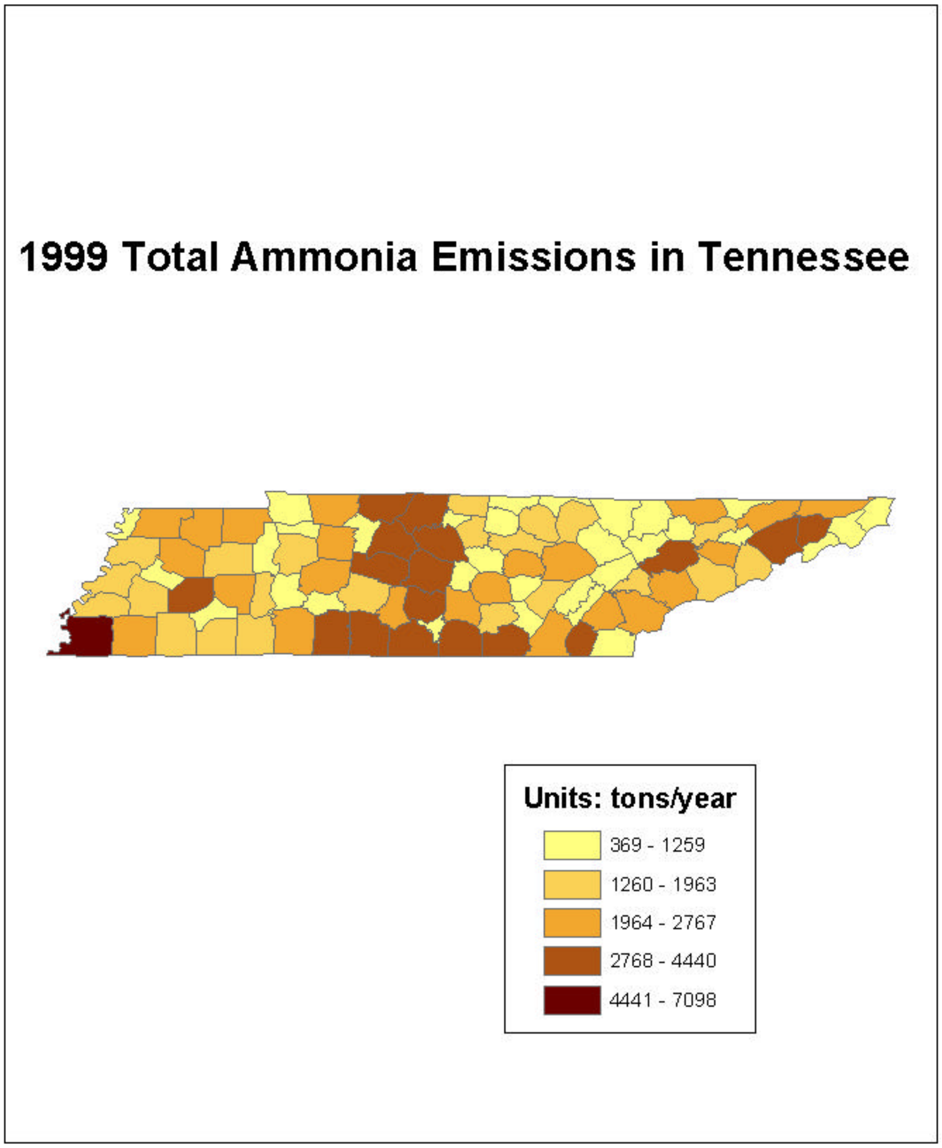

Fig 4-2. Total Ammonia Emission Estimates for 1999

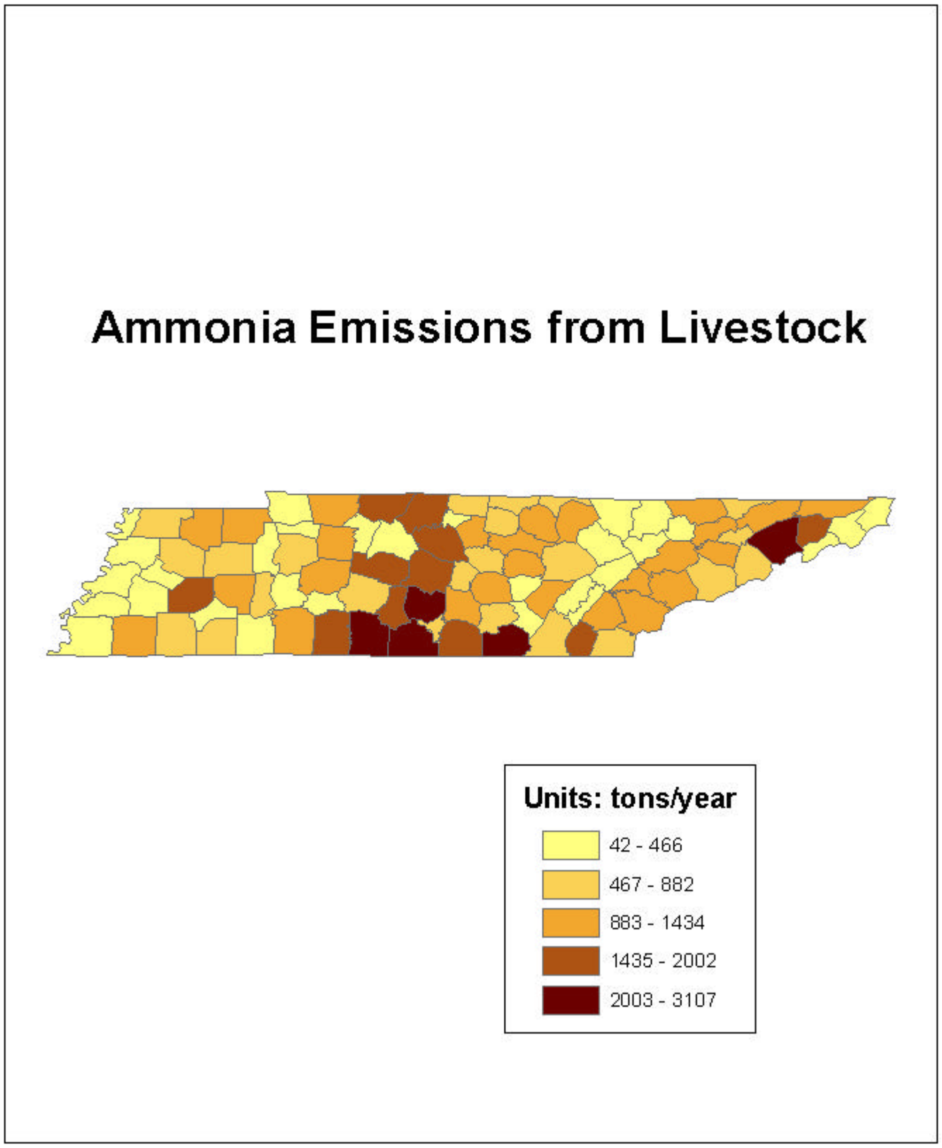

Fig 4-3. Ammonia Emission Estimates from Livestock for 1999

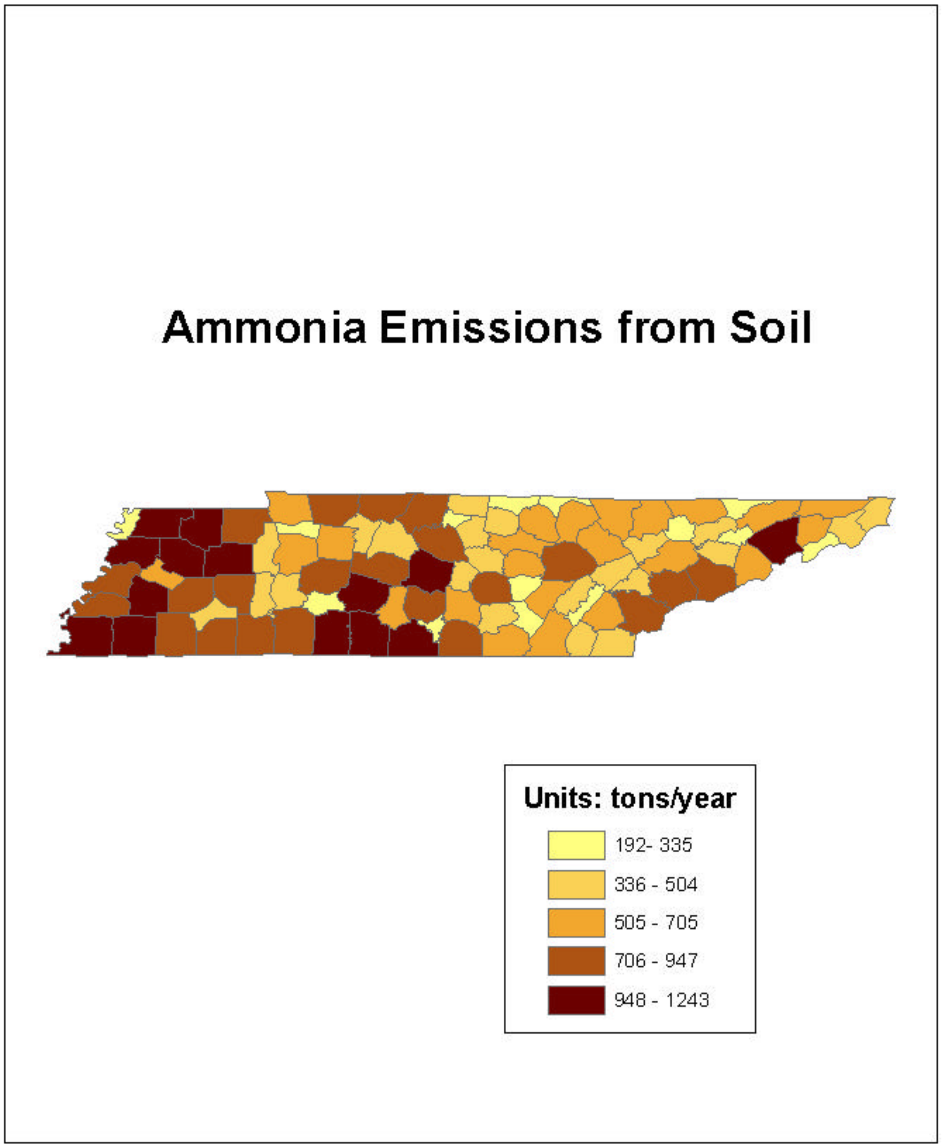

Fig 4-4. Ammonia Emission Estimates from Soil for 1999

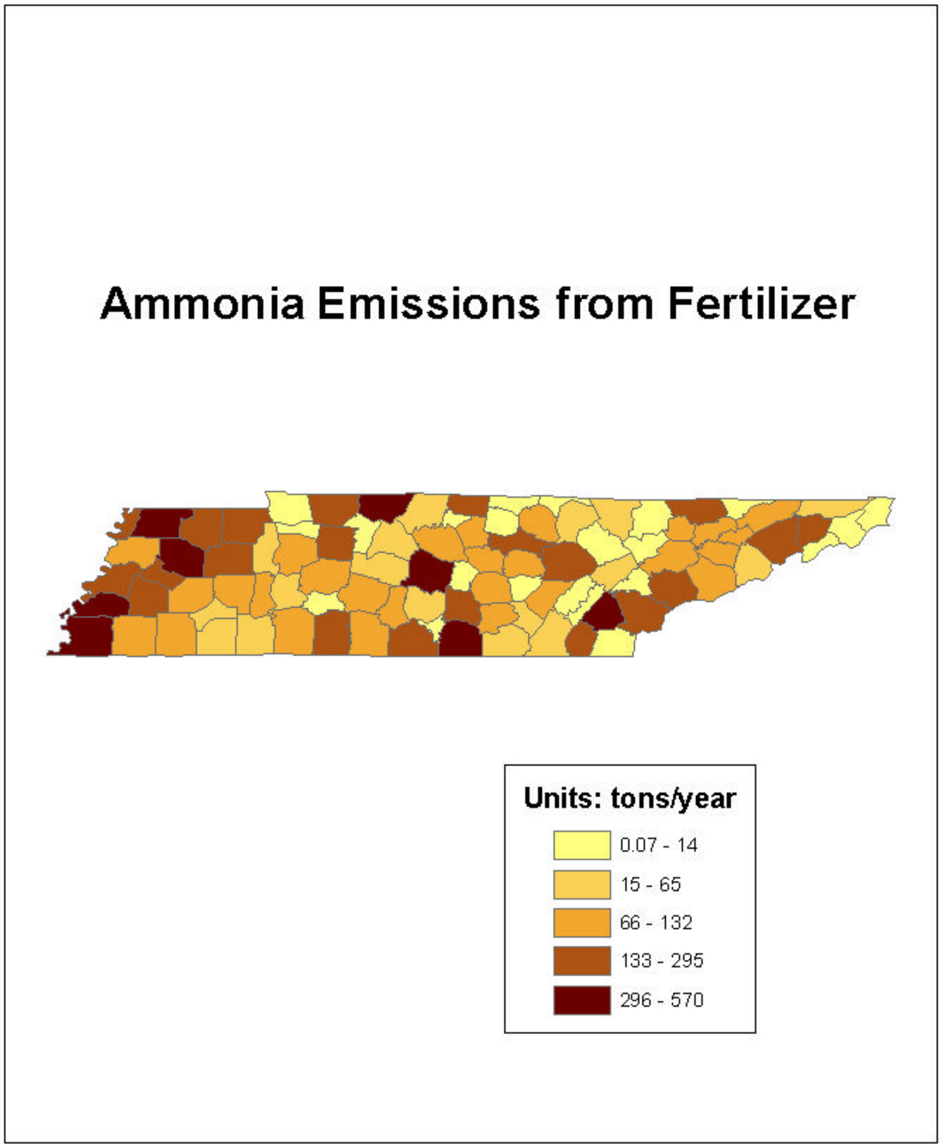

Fig 4-5. Ammonia Emission Estimates from Fertilizer for 1999

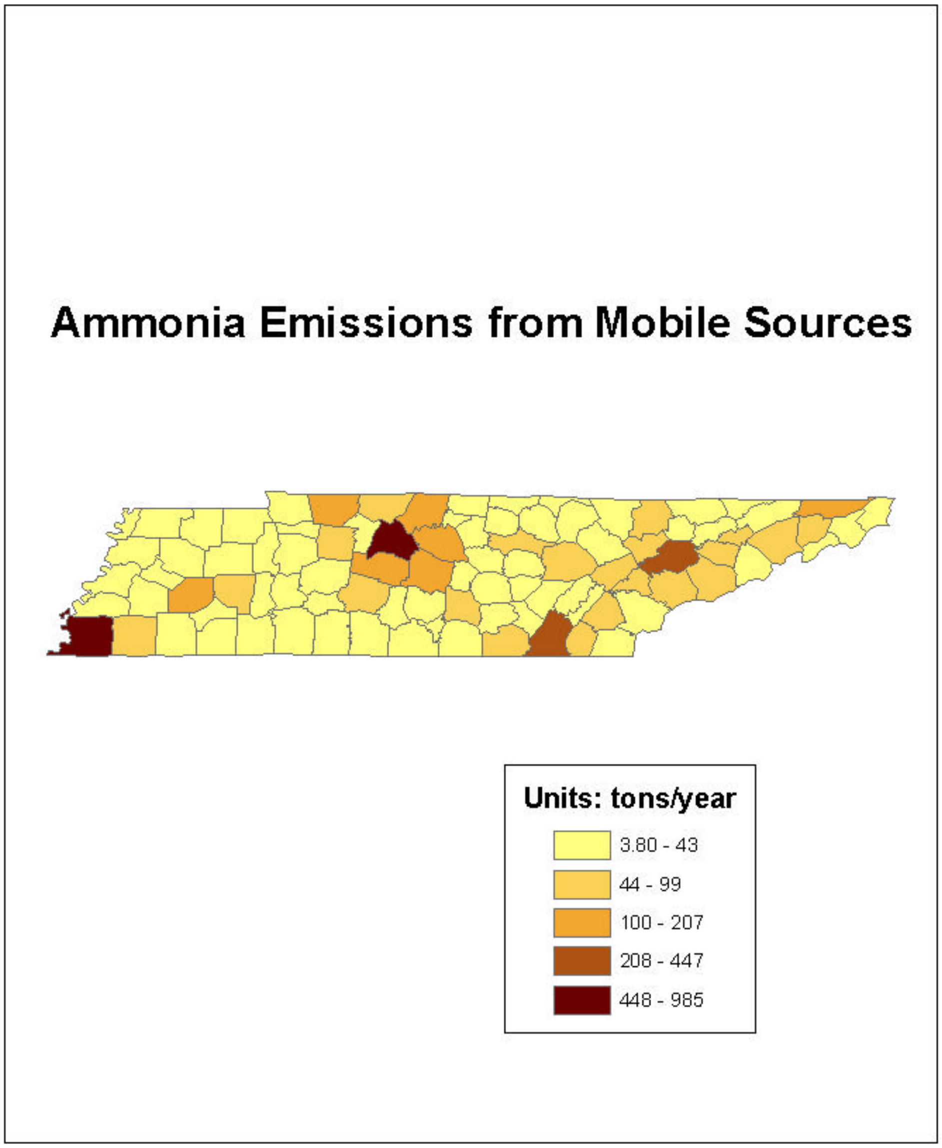

Fig 4-6. Ammonia Emission Estimates from Mobile Sources for 1999

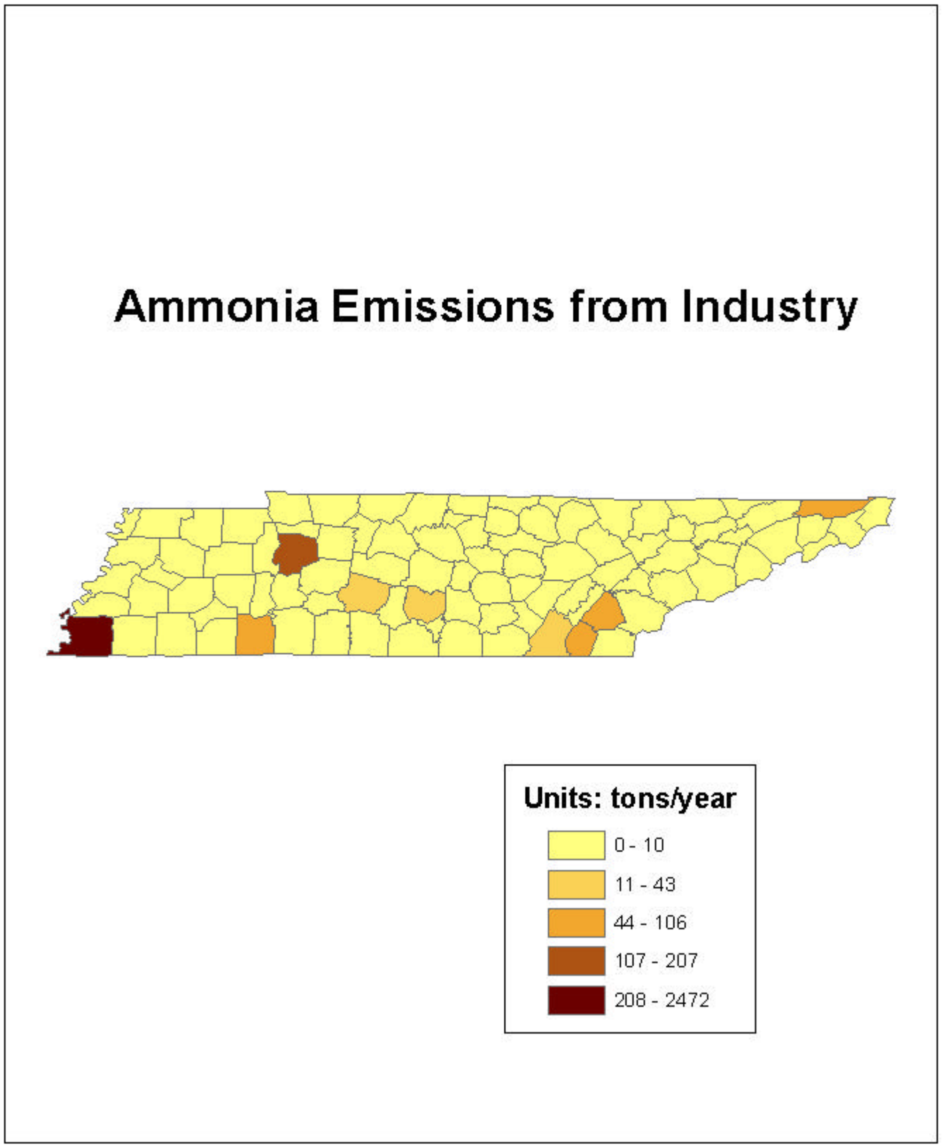

Fig 4-7. Ammonia Emission Estimates from Industry for 1999

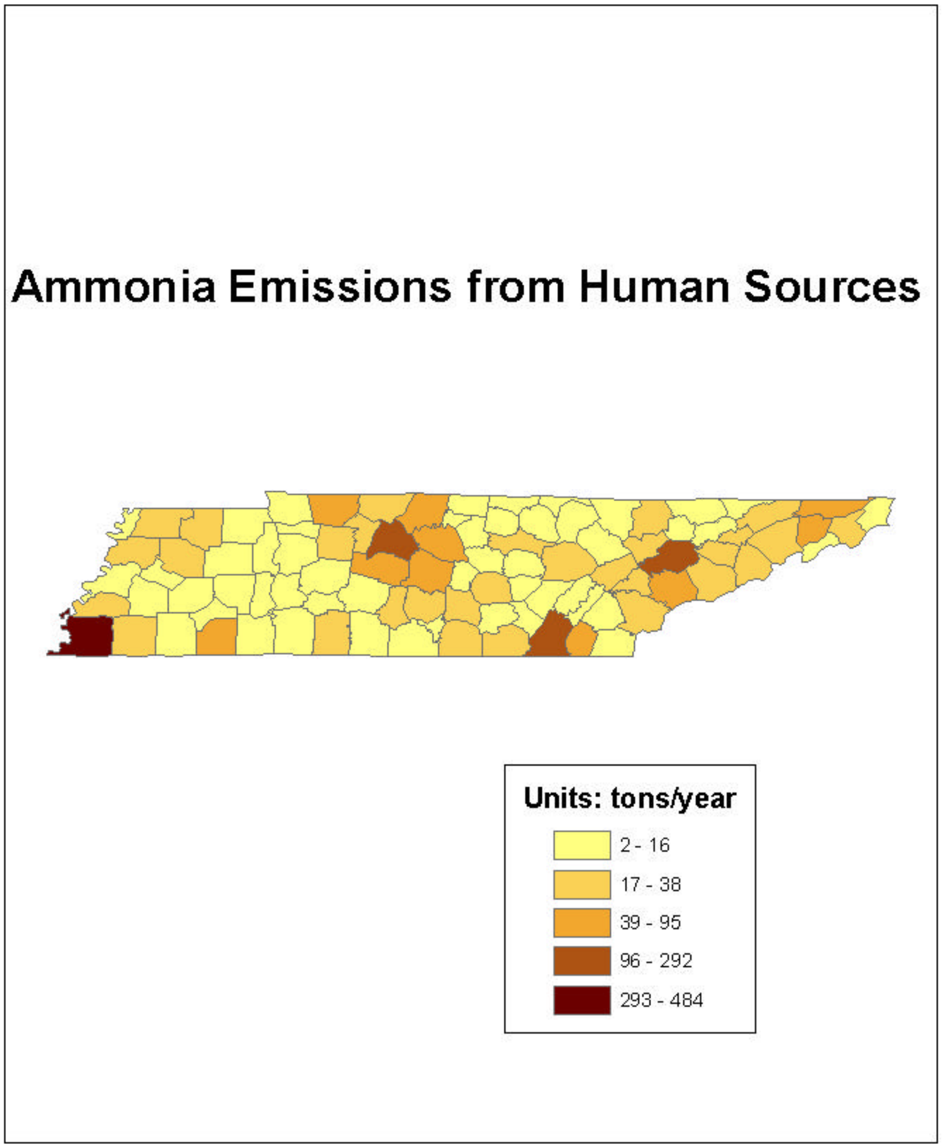

Fig 4-8. Ammonia Emission Estimates from Human Sources for 1999

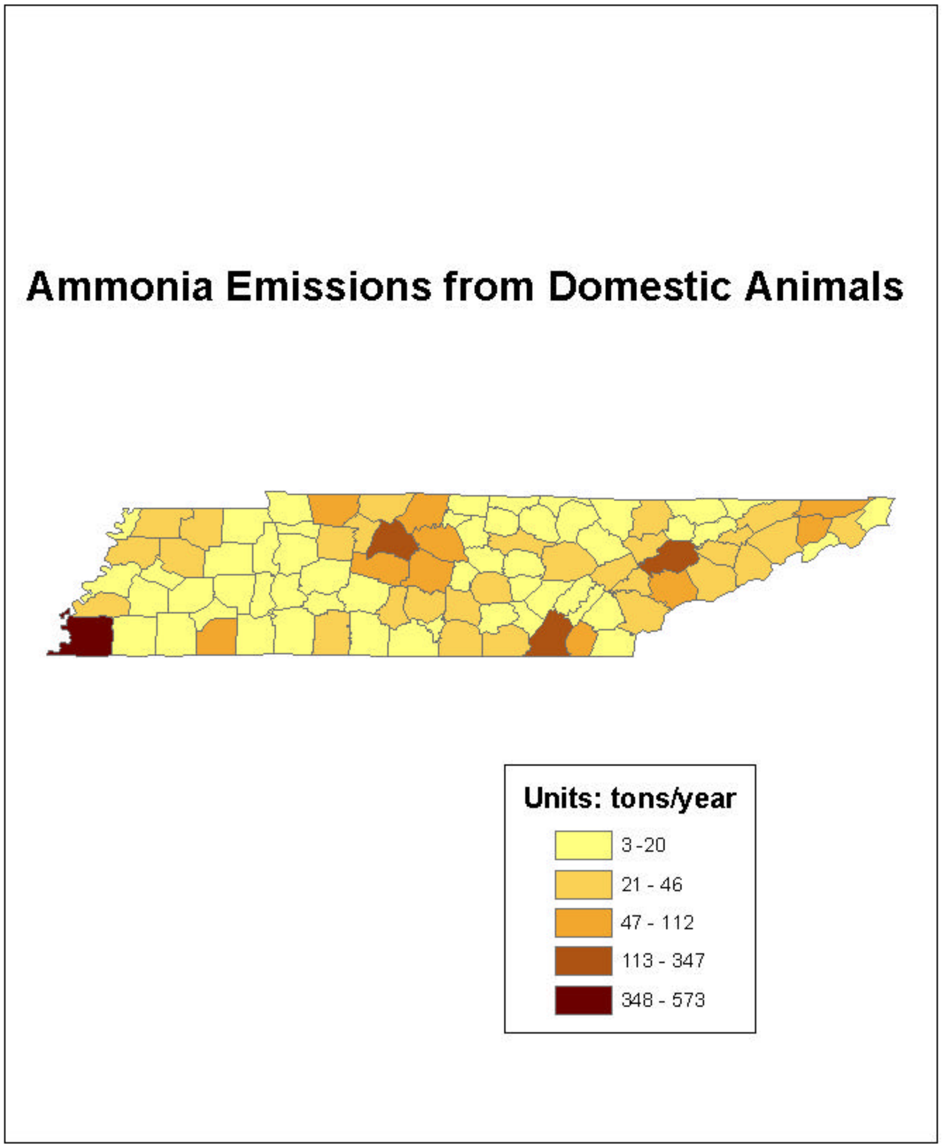

Fig 4-9. Ammonia emission Estimates from Domestic Animals for 1999

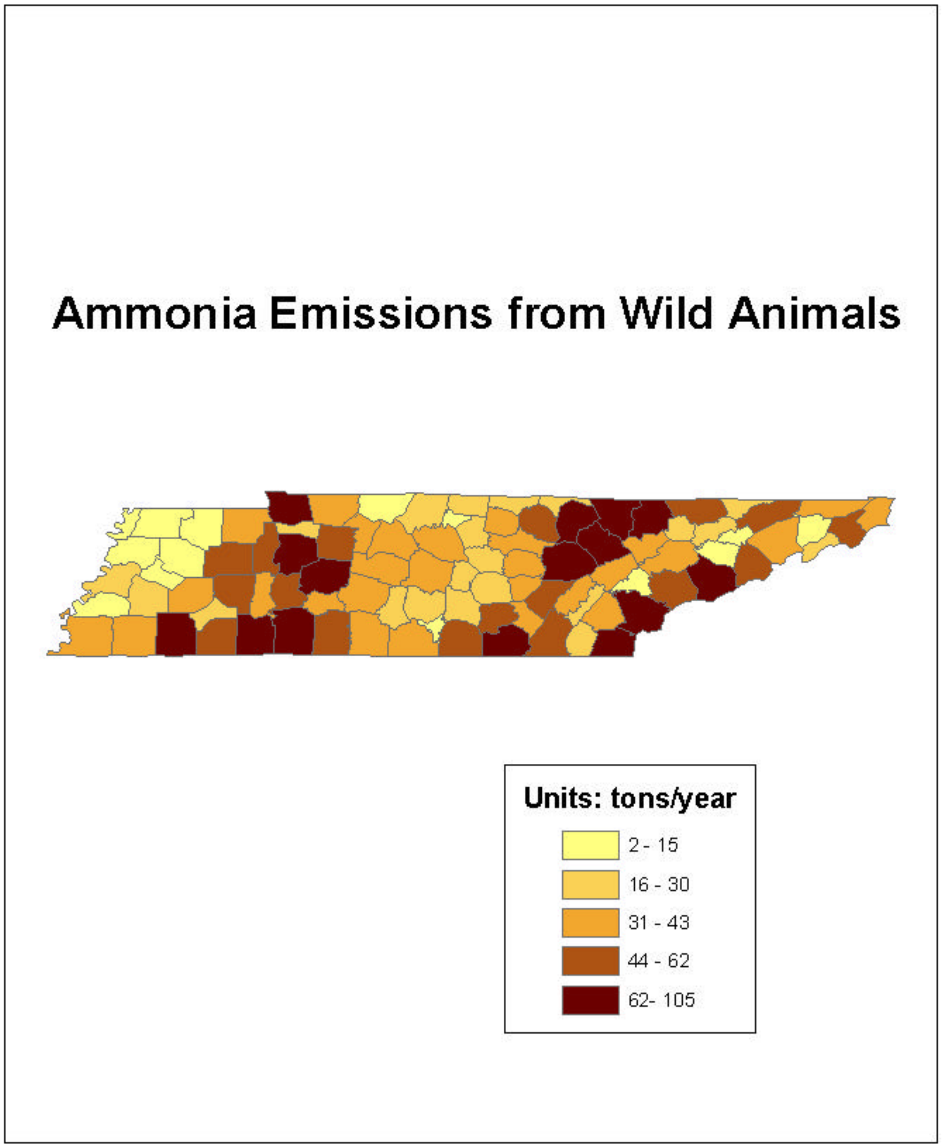

Fig 4-10. Ammonia Emission Estimates from Wild Animals for 1999

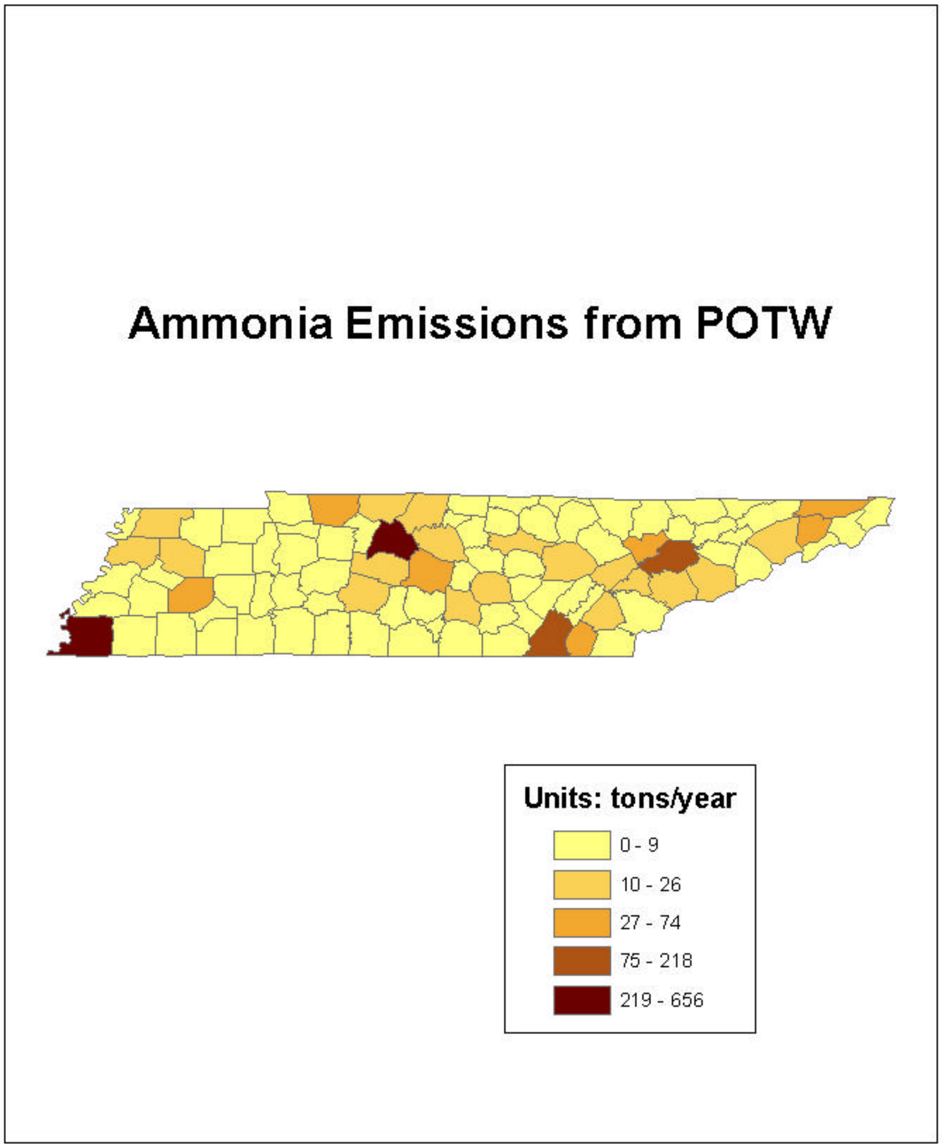

Fig 4-11. Ammonia Emission Estimates from POTW for 1999

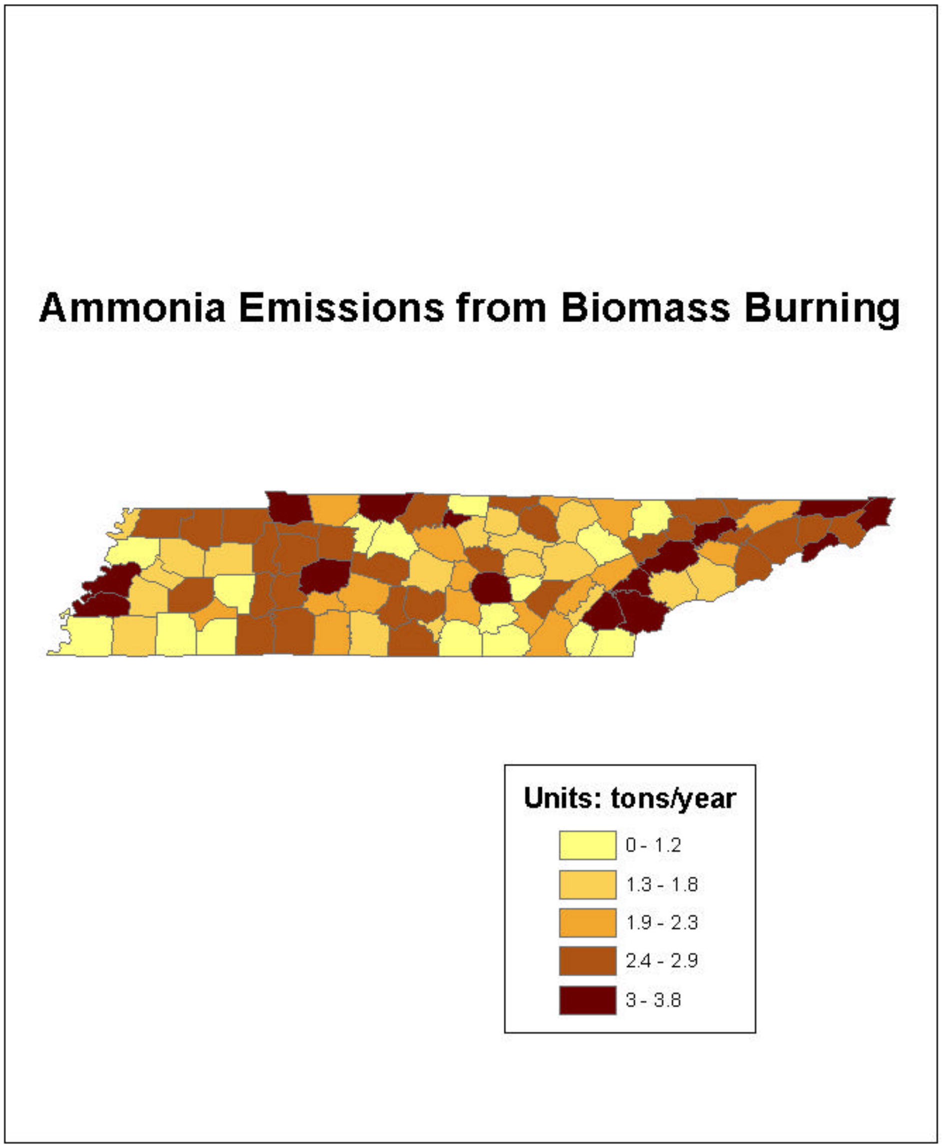

Fig 4-12. Ammonia Emission Estimates from Biomass Burning for 1999

Table 4-3. Ammonia Emission Estimates from the 12 counties with the Emissions =3100 (tons/year)

Fips	County_name	Soil	Livestock	Mobile	Fertilizer	Industry	Wild Animal	POTW	Domestic Animal	Human	Biomass Burning	NH3 Total (ton/yr)
47003	Bedford	867.27	3106.83	34.79	59.55	17.87	19.37	7.45	22.89	19.22	2.37	4157.61
47051	Franklin	809.32	1738.99	31.81	466.25	0.00	49.13	5.30	24.81	20.69	1.15	3147.44
47055	Giles	1053.13	2335.74	41.15	68.86	0.00	42.74	7.13	19.04	15.96	1.45	3585.21
47059	Greene	1080.67	2962.52	80.87	193.22	0.15	34.78	12.11	39.94	33.22	2.54	4440.02
47099	Lawrence	995.40	2002.77	32.83	154.89	0.00	50.65	7.16	25.99	21.89	1.83	3293.41
47103	Lincoln	1014.87	2682.80	29.72	224.27	0.10	31.13	7.51	19.53	16.35	2.79	4029.06
47115	Marion	594.58	2265.21	63.40	59.58	0.00	72.70	2.90	46.20	38.82	1.20	3144.60
47147	Robertson	946.58	1775.09	79.87	448.39	0.00	11.76	15.60	35.98	30.38	3.18	3346.84
47149	Rutherford	1000.55	1653.07	207.82	539.59	0.08	34.49	39.63	112.42	95.07	1.36	3684.08
47157	Shelby	1093.13	426.46	984.15	377.57	2471.02	32.69	655.04	572.58	483.97	1.28	7097.89
47187	Williamson	910.54	1873.32	144.20	35.37	0.00	40.76	11.07	81.19	68.32	2.52	3167.29
47189	Wilson	900.43	1987.30	122.54	94.99	0.00	37.86	14.83	56.73	47.73	2.11	3264.51
Total												**46,357.97**
% of Total Ammonia Emissions												**25%**

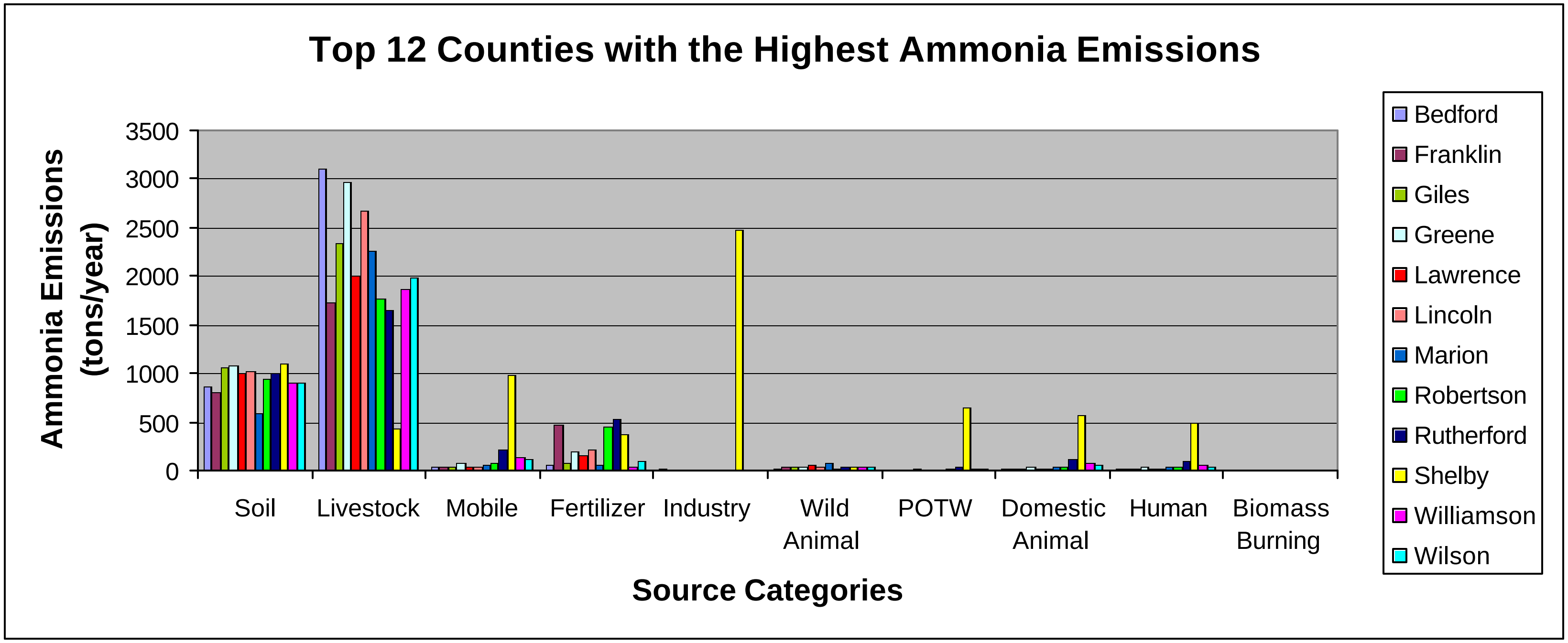

Fig 4-13. Ammonia Emission Estimates from the 12 counties

Table 4-4. Ten Largest Ammonia Emission Estimates from Sub-Source Categories in Tennessee for 1999

Rank	Sub-Source Category	Ammonia Emissions (tons/year)
1	Beef Cows	45,097
2	Agricultural Land	36,993
3	Cattle & Calves	26,505
3	Forest Land	21,933
4	Urea	6,164
5	Broilers	4,633
6	Milk Cows	4,379
7	LDGV	3,709
8	Deer	3,703
9	Industry	3,136
10	Dogs	2,650

4-5 presents ammonia emissions in four urban counties. Fig 4-14 shows the ammonia emissions for urban counties.

Industrial sources based on the TRI (TRI, 1999) were the single largest source for Shelby County, which was reported as having the largest ammonia emission estimates in Tennessee for 1999.

As shown in Table 4-5, for these urban counties, mobile sources are expected to contribute 18% of ammonia emissions. For these counties, POTWs sources are responsible for contributing over 11% of ammonia emissions. Livestock sources are predicted to be a major source even in urban counties like Knox and Hamilton. Soils are responsible for emitting slightly more than 20% of ammonia emissions for these urban counties.

Ammonia emission estimates are uncertain because most emission factors for ammonia are not obtained by experimental data based on research. More research in ammonia emission factors is needed. Most emission factors used in this study were obtained from published literature, which is the most appropriate way at the present to calculate ammonia emission estimates. However, the emission factors for soils used in this study were subject to be particularly uncertain because they were not generic emission factors that account for all soil types. Even though ammonia emissions from soil are uncertain, soil should be included in the ammonia emission source category as a major source.

Another important thing is to obtain more precise and appropriate activity data for each sub-source category. Activity data for fertilizers were obtained as yearly averages in

Table 4-5. Ammonia Emissions in Several Urban Counties

Fips	County_name	Soil	Livestock	Mobile Sources	Fertilizer	Industry	Wild Animals	POTW	Domestic Animals	Humans	Biomass Burning	NH3 Total (ton/yr)
47037	Davidson	337.76	378.68	790.72	45.34	0.02	34.78	527.55	347.64	292.33	0.93	**2755.76**
47093	Knox	278.32	966.40	446.71	119.55	5.79	31.74	218.37	246.63	206.48	2.90	**2522.89**
47065	Hamilton	447.45	607.01	360.48	25.34	43.31	55.85	218.16	193.30	161.84	2.04	**2114.79**
47157	Shelby	344.62	426.46	984.15	377.57	2471.02	32.69	655.04	572.58	483.97	1.28	**6349.38**

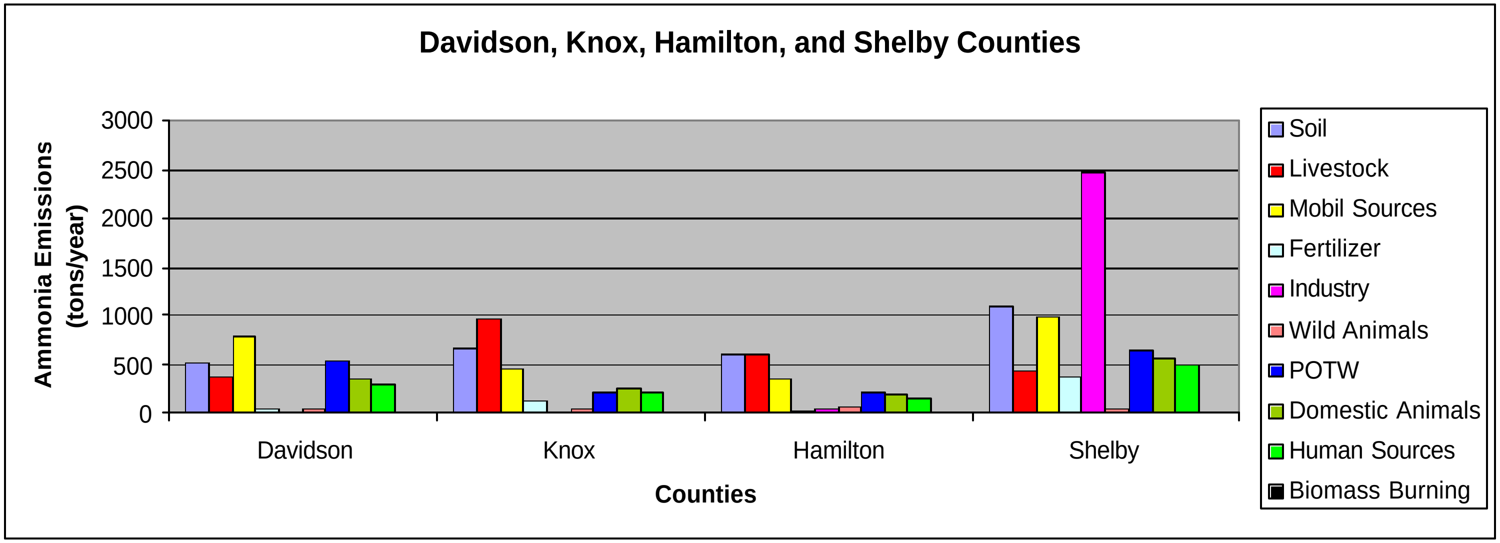

Fig 4-14. Ammonia emissions for Knox, Davidson, Hamilton, and Shelby Counties

the study. Ammonia emissions from livestock and fertilizers are believed to have strong temporal components with more fertilizers being applied in the spring and fall than in the summer and winter. Because ammonia emissions from livestock increase with temperature (Roberge et al., 2002), seasonal and daily emission estimates are needed to serve as input data for modeling $PM_{2.5}$ formation. Yearly fertilizer averages were used in this study due to the lack of information about monthly averages. To improve estimates of ammonia emission from fertilizer, fertilizer application times and rates should be compiled based on a monthly distribution. Monthly and daily default fractions would be used to temporally allocate ammonia emission estimates for source categories (shown in Table 3-28).

The base year for this study was 1999. Ammonia emissions from a few sub-source categories such as ducks, geese, turkeys, and wild animals were based on 1997 data because no activity data were available for the year 1999.

The other thing that should be researched is the potential for other sources of ammonia emissions. Fifty-four sub-source categories were used in this study. However, there may be other emission sources, not yet identified. For the future, improvement of ammonia emission estimates, available activity data, accurate emission factors, and further research on potential sources should be continuously studied to generate more accurate ammonia emission estimates.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

This study has estimated annual ammonia emissions from 54 sub-source categories on a county basis for the state of Tennessee. The base year of the study was 1999. Ammonia emission estimations were made separately for all 95 counties in Tennessee. The conclusions in this study are listed below:

- Livestock is the major source of total ammonia emissions in Tennessee, responsible for emitting 87,924 tons per year, with beef cows emitting 45,097 tons of ammonia emissions, forming the biggest sub-source category within the livestock category.
- Even though soils may be an uncertain source category of ammonia emissions, soils emitted 60,999 tons of ammonia emissions as the second largest contributor.
- Yearly ammonia emissions from fertilizers were considered in this study. However, monthly fertilizer ammonia emissions are likely to be more accurate than yearly averages for the temporal profile. Annual fertilizer usage was used with temporal default plots to allocate ammonia emissions from fertilizer. It would be better to have monthly application rates so the default file would not be needed. Fertilizer ammonia emissions were found to be the third largest contributor, estimated at 11,504 tons per year, with urea emitting 6,164 tons of ammonia emissions for Tennessee in 1999.

- In Knox, Davidson, Hamilton, and Shelby counties, the total emission magnitudes from soil sources were larger than those of livestock sources.

As a result of the study, ammonia emission estimates are available on a county-level basis and can be used for modeling $PM_{2.5}$ for Tennessee. In particular, ammonia emission estimates from area sources can be useful for modeling $PM_{2.5}$ as input data. In addition, the spatial surrogates for area sources are identified in this study for modeling.

Additional research is needed to more accurately estimate ammonia emissions, including the development of emission factors and the development of more refined temporal allocations for fertilizers and livestock sources.

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APPENDIX

APPENDIX A

ACTIVITY DATA FOR SUB-SOURCE CATEGORIES BY COUNTY IN TENNESSEE

Table A1. Activity level for livestock by county in Tennessee

CNTY_NAME	MCOWS	BCOWS	Cattle and Calves Composite	HOG & PIG	BROILERS	Layers(>1yr)	Layers(<1yr)	Pullets(>13 Weeks)	Pullets(<13 Weeks)	Other Chickens	Horses and Ponies Composite	Sheep and Lambs Compos	Goats	DUCKS	GEESE	TURKEYS
Anderson	163	4500	4817	406	0	0	0	0	0	0	552	162	253	21	7	95
Bedford	3000	25000	25046	4000	4249928	108867	426850	166476	198229	77120	3683	201	2595	386	117	29
Benton	83	5000	4576	1500	0	0	0	0	0	0	862	0	165	53	54	21
Bledsoe	1000	11800	12523	215	91325	2340	9173	3578	4260	1657	646	133	112	90	7	18
Blount	1500	15000	15413	406	0	0	0	0	0	0	1810	496	134	77	54	19
Bradley	2900	10500	14450	406	3834830	98244	385197	150231	178885	69589	1670	138	253	109	80	29
Campbell	163	4000	3612	406	0	0	0	0	0	0	251	20	295	90	7	0
Cannon	1100	9600	10115	3500	0	0	0	0	0	0	1458	139	3455	120	49	29
Carroll	83	9500	8188	3800	0	0	0	0	0	0	892	0	172	86	52	29
Carter	600	3800	5057	406	0	0	0	0	0	0	852	54	233	43	7	0
Cheatham	67	6100	5298	500	0	0	0	0	0	0	969	0	116	63	30	26
Chester	83	4600	4094	850	0	0	0	0	0	0	236	7	20	90	7	0
Claiborne	900	18000	17339	406	32519	833	3266	1274	1517	590	458	222	104	90	7	10
Clay	160	8100	6743	840	959864	24591	96415	37603	44775	17418	234	11	142	128	19	27
Cocke	1200	8100	8429	406	320113	8201	32154	12541	14932	5809	524	89	176	71	7	41
Coffee	2300	11500	14450	2300	346223	8870	34777	13563	16150	6283	1636	208	1085	92	7	29
Crockett	83	3700	3372	850	0	0	0	0	0	0	429	37	131	41	7	29
Cumberland	1500	9000	10115	2500	67478	1729	6778	2643	3148	1224	942	545	622	92	54	126
Davidson	160	5000	4576	840	0	0	0	0	0	0	1039	0	307	33	7	0
Decatur	700	12600	11078	840	0	0	0	0	0	0	369	0	403	90	7	0
De Kalb	83	7000	6261	2600	0	0	0	0	0	0	750	101	1366	90	7	29
Dickson	67	14000	13486	1200	0	0	0	0	0	0	1297	18	1089	137	39	102
Dyer	67	5400	5298	900	104729	2683	10520	4103	4885	1900	638	37	82	33	7	12
Fayette	800	12800	11560	16000	0	0	0	0	0	0	2320	122	231	43	11	0
Fentress	800	7800	8188	600	1741414	44613	174920	68220	81233	31601	705	81	785	25	30	37
Franklin	2500	14000	15894	10000	1839907	47136	184813	72079	85827	33388	1262	109	995	71	76	25
Gibson	83	9600	10115	6000	0	0	0	0	0	0	973	79	171	116	7	29
Giles	2500	29000	32271	5700	51523	1320	5175	2018	2403	935	2399	302	1519	186	31	90
Grainger	1000	12000	12523	406	0	0	0	0	0	0	935	203	369	52	7	55
Greene	7000	33000	34197	406	1101595	28221	110652	43155	51387	19990	2080	213	748	112	18	29
Grundy	243	3200	3853	600	1872101	47961	188047	73340	87329	33972	258	32	546	90	7	29
Hamblen	1100	8400	8188	700	351210	8998	35278	13759	16383	6373	663	451	190	137	7	5
Hamilton	700	6700	6984	406	307945	7889	30932	12064	14365	5588	803	119	281	266	76	29
Hancock	163	7300	7225	406	0	0	0	0	0	0	379	67	263	20	7	38
Hardeman	83	9100	7466	3000	0	0	0	0	0	0	583	144	293	53	7	29
Hardin	83	6000	5780	2000	0	0	0	0	0	0	486	7	1056	90	29	29
Hawkins	800	18500	17821	406	81299	2083	8166	3185	3792	1475	1253	288	655	161	51	45
Haywood	83	3400	3131	1100	0	0	0	0	0	0	385	0	81	90	7	29
Henderson	83	12500	13968	8000	0	0	0	0	0	0	812	225	268	61	18	0
Henry	1900	8800	10115	41000	36584	937	3675	1433	1707	664	809	97	202	38	26	8
Hickman	67	13800	12523	2700	0	0	0	0	0	0	1147	5	340	116	40	23
Houston	67	5100	5539	250	0	0	0	0	0	0	370	35	4	90	7	0
Humphreys	67	9200	9151	700	0	0	0	0	0	0	561	0	569	72	49	29
Jackson	160	7300	6021	840	0	0	0	0	0	0	373	7	1273	89	7	18
Jefferson	1800	16000	17821	406	341454	8748	34298	13377	15928	6196	1254	643	410	56	24	47
Johnson	163	4300	5057	406	0	0	0	0	0	0	422	133	296	30	7	29
Knox	700	12200	12523	406	65039	1666	6533	2548	3034	1180	2250	711	577	93	41	20
Lake	67	600	433	100	0	0	0	0	0	0	31	0	43	90	7	0
Lauderdale	67	5000	4142	900	0	0	0	0	0	0	390	0	133	90	7	0
Lawrence	2900	26000	24564	4600	44138	1131	4434	1729	2059	801	1988	137	1514	238	33	59
Lewis	67	3400	2890	900	0	0	0	0	0	0	212	77	67	90	7	29
Lincoln	3700	32000	32752	3200	768000	19675	77143	30087	35825	13937	2109	443	1065	120	85	29
Loudon	3700	11000	13486	406	0	0	0	0	0	0	1339	341	330	98	32	29
McMinn	160	15000	13005	3200	342809	8782	34434	13430	15991	6221	1195	26	1597	293	47	7

Table A1. Activity level for livestock by county in Tennessee (Cont.)

CNTY_NAME	MCOWS	BCOWS	Cattle and Calves Composite	HOG & PIG	BROILERS	Layers(>1yr)	Layers (<1yr)	Pullets(>13 Weeks)	Pullets(<13 Weeks)	Other Chickens	Horses and Ponies Composite	Sheep and Lambs Compos	Goats	DUCKS	GEESE	TURKEYS
McNairy	83	6000	5780	9500	0	0	0	0	0	0	995	0	207	93	7	0
Macon	243	4400	4335	215	937507	24018	94170	36727	43732	17013	275	7	256	90	7	0
Madison	4100	18500	20711	3700	49429	1266	4965	1936	2306	897	2860	210	1700	263	30	7
Marion	2500	30000	30826	600	0	0	0	0	0	0	1987	378	1003	155	16	11
Marshall	6200	14600	19266	406	844495	21635	84827	33083	39394	15325	1727	5	274	54	56	69
Maury	83	5800	5298	7800	0	0	0	0	0	0	1258	102	1128	60	39	29
Meigs	800	5500	5298	406	0	0	0	0	0	0	406	0	29	51	7	29
Monroe	4700	11400	15413	406	0	0	0	0	0	0	875	98	192	110	7	9
Montgomery	600	16000	14450	900	2439	62	245	96	114	44	981	42	401	301	110	31
Moore	600	7000	6502	840	338513	8672	34003	13261	15791	6143	572	78	1121	47	73	29
Morgan	243	4600	4335	215	273976	7019	27520	10733	12780	4972	259	13	465	90	7	29
Obion	67	8400	9633	600	723334	18531	72657	28337	33742	13126	583	174	58	90	7	0
Overton	1400	15000	13486	600	137123	3513	13774	5372	6396	2488	853	61	549	366	53	298
Perry	67	3100	3131	500	0	0	0	0	0	0	488	0	36	90	7	30
Pickett	243	5900	5298	215	342809	8782	34434	13430	15991	6221	276	0	1	38	7	18
Polk	1800	2300	4335	406	1263175	32361	126882	49485	58924	22922	132	0	11	90	7	29
Putnam	700	12500	12041	600	0	0	0	0	0	0	1041	0	1461	92	42	15
Rhea	500	5100	5780	406	4878	125	490	191	228	89	241	0	129	26	7	9
Roane	163	6000	5780	406	32519	833	3266	1274	1517	590	660	149	190	16	7	10
Robertson	3200	22000	23119	4100	30487	781	3062	1194	1422	553	1390	333	148	197	7	0
Rutherford	2300	20000	20711	2300	41855	1072	4204	1640	1952	760	3953	413	3386	328	111	9
Scott	243	2300	2408	215	221945	5686	22294	8695	10353	4028	486	56	43	90	7	0
Sequatchie	243	2800	3612	215	71814	1840	7213	2813	3350	1303	122	0	133	90	7	29
Sevier	163	9500	9633	406	166662	4270	16741	6529	7774	3024	1770	297	314	96	17	29
Shelby	67	5200	4576	600	0	0	0	0	0	0	2735	165	304	91	55	6
Smith	700	17000	14931	1200	0	0	0	0	0	0	1127	429	1864	82	36	6
Stewart	67	5000	4335	250	0	0	0	0	0	0	300	5	371	62	7	29
Sullivan	800	13000	14931	406	0	0	0	0	0	0	1623	4	679	63	7	29
Sumner	1500	22000	22638	1800	9756	250	980	382	455	177	2717	35	1521	105	39	18
Tipton	67	5400	4817	100	0	0	0	0	0	0	307	81	219	105	36	29
Trousdale	160	6900	5539	840	0	0	0	0	0	0	221	180	497	90	0	0
Unicoi	163	700	722	406	0	0	0	0	0	0	333	0	43	100	7	29
Union	163	5600	5298	406	0	0	0	0	0	0	434	41	109	38	7	14
Van Buren	243	3700	4094	215	0	0	0	0	0	0	163	0	212	90	7	0
Warren	1700	18500	18303	1900	0	0	0	0	0	0	1110	145	1037	98	19	12
Washington	5000	23000	26491	406	65039	1666	6533	2548	3034	1180	1623	326	992	89	37	14
Wayne	67	13300	11560	1400	9553	245	960	374	446	173	766	85	692	44	15	7
Weakley	1100	8200	8670	49000	644971	16523	64785	25267	30086	11704	887	158	461	435	354	7
White	2900	18000	18784	1600	2439	62	245	96	114	44	971	34	695	62	24	27
Williamson	1500	24000	24083	1700	0	0	0	0	0	0	4716	819	949	143	56	29
Wilson	1000	27000	25528	2700	0	0	0	0	0	0	3022	235	2167	225	91	13
Total	**100006**	**1030000**	**1050000**	**186134**	**25166667**	**644738**	**2527912**	**985912**	**1173961**	**456690**	**85947**	**10850**	**48373**	**8732**	**2257**	**2356**

Table A2. Activity level for Soil by county in Tennessee

CNTY_NAME	URBAN (km^2)	FOREST (km^2)	WETLAND (km^2)	AGRICULTURE (km^2)
Anderson	247.64	564.27	0.00	132.33
Bedford	933.38	289.09	0.46	880.01
Benton	232.59	736.46	22.96	217.87
Bledsoe	314.46	712.83	1.22	303.52
Blount	601.42	849.32	0.65	480.39
Bradley	406.38	420.19	4.88	314.51
Campbell	194.59	945.23	0.02	124.05
Cannon	324.90	330.15	0.19	309.29
Carroll	805.04	674.59	80.71	774.52
Carter	208.13	708.18	0.08	161.72
Cheatham	260.47	502.78	12.96	208.80
Chester	314.11	426.99	2.87	311.45
Claiborne	458.03	648.32	2.22	443.15
Clay	214.99	397.77	0.00	193.46
Cocke	362.46	798.71	10.74	329.53
Coffee	638.07	427.63	12.97	555.94
Crockett	615.13	51.16	4.17	608.37
Cumberland	400.22	1269.90	1.90	326.33
Davidson	774.60	511.52	1.55	230.40
Decatur	244.81	612.46	20.55	239.71
De Kalb	345.58	440.33	0.00	312.86
Dickson	488.28	769.92	0.50	426.11
Dyer	1106.34	184.78	37.00	1078.41
Fayette	1191.69	612.47	0.18	1182.02
Fentress	262.13	993.90	0.00	228.64
Franklin	660.96	734.50	12.19	586.03
Gibson	1384.53	151.37	28.55	1341.23
Giles	973.79	630.75	1.18	934.96
Grainger	351.18	377.14	13.69	343.24
Greene	1077.88	523.38	0.00	1022.20
Grundy	155.20	771.22	0.00	126.78
Hamblen	309.96	102.00	8.05	252.80
Hamilton	608.44	810.71	4.28	227.86
Hancock	189.04	373.76	0.00	186.53
Hardeman	580.49	1013.55	121.72	571.03
Hardin	503.42	953.93	16.73	495.37
Hawkins	543.21	692.30	9.54	491.92
Haywood	1070.15	289.17	47.44	1056.28
Henderson	542.09	779.85	14.55	528.90
Henry	808.91	507.28	93.27	784.48
Hickman	389.37	1187.41	0.00	364.31
Houston	111.89	387.18	0.18	97.79
Humphreys	328.87	992.37	13.47	281.65
Jackson	235.20	561.88	2.07	210.98
Jefferson	480.60	234.52	34.82	445.16
Johnson	233.14	550.16	0.33	225.80
Knox	833.47	466.24	0.21	488.15
Lake	358.97	34.87	30.40	352.73
Lauderdale	818.48	382.05	2.15	803.60

Table A2. Activity level for Soil by county in Tennessee (Cont.)

CNTY_NAME	URBAN (km^2)	FOREST (km^2)	WETLAND (km^2)	AGRICULTURE (km^2)
Lawrence	77.03	733.69	3.89	806.34
Lewis	30.06	598.37	0.52	101.27
Lincoln	60.86	462.79	14.28	963.91
Loudon	67.16	203.76	0.00	333.92
McMinn	91.34	533.73	9.23	471.29
McNairy	7.51	935.41	18.43	478.72
Macon	35.14	390.90	0.00	385.90
Madison	49.20	518.51	60.94	824.41
Marion	73.79	1073.81	0.00	171.44
Marshall	41.34	329.66	0.00	579.54
Maury	103.37	557.07	0.20	913.24
Meigs	29.52	311.00	11.30	162.65
Monroe	87.82	1201.84	5.68	384.18
Montgomery	159.19	578.78	7.65	661.83
Moore	11.24	128.47	3.17	189.11
Morgan	96.19	1125.49	0.00	117.64
Obion	24.45	194.67	123.33	1078.50
Overton	49.05	680.52	0.50	391.14
Perry	25.90	870.07	7.95	150.05
Pickett	17.95	302.13	0.00	116.96
Polk	97.82	907.24	0.00	124.15
Putnam	131.96	526.23	0.32	383.28
Rhea	75.47	512.84	9.60	227.34
Roane	131.38	626.85	3.57	174.88
Robertson	75.45	175.69	4.83	1022.92
Rutherford	133.99	517.13	2.88	911.90
Scott	110.52	1206.27	0.00	67.82
Sequatchie	38.64	536.46	0.00	113.41
Sevier	53.42	1139.46	3.53	362.15
Shelby	496.08	439.44	93.78	925.99
Smith	40.04	335.49	0.00	405.87
Stewart	63.62	966.55	10.56	154.15
Sullivan	159.72	492.49	0.51	409.85
Sumner	137.68	420.42	0.42	827.54
Tipton	15.00	225.77	9.13	856.77
Trousdale	13.70	111.40	0.00	172.19
Unicoi	18.75	461.28	0.00	37.36
Union	6.68	355.21	4.97	193.10
Van Buren	30.62	533.26	0.00	87.17
Warren	53.00	401.09	1.89	694.82
Washington	78.32	200.44	0.08	563.19
Wayne	168.44	1421.77	1.67	310.32
Weakley	26.91	219.35	114.04	1105.84
White	45.04	483.34	2.14	449.24
Williamson	131.75	609.63	0.00	761.86
Wilson	113.87	570.66	0.30	773.42
Total	7116.70	54512.97	1204.86	43991.70

Table A3. Activity level for Fertilizer by county in Tennessee

CNTY_NAME	Anhydrous Ammonia(ton)	Nitrogen Solutions(ton)	Urea (ton)	Ammonium Nitrate (ton)	Ammonium Sulfate (ton)	Ammonium Thiosulfate (ton)	Other Straight Nitrogen (ton)	Ammonium Phosphates (ton)	N-P-K (ton)
Anderson	0.42	1.44	20.79	18.38	0.00	0.00	20.81	6.12	178.14
Bedford	0.00	0.71	139.19	700.11	0.00	0.00	139.20	204.83	55.99
Benton	0.00	0.35	147.44	184.00	0.00	0.00	147.45	118.57	32.60
Bledsoe	0.00	0.26	421.12	493.34	0.00	0.00	421.12	277.71	167.46
Blount	0.00	119.62	632.61	79.88	0.00	0.00	632.84	201.08	229.16
Bradley	0.00	27.16	1179.86	205.08	0.10	0.00	1006.56	455.53	334.11
Campbell	0.00	0.76	0.04	11.15	0.00	0.00	0.00	0.00	89.98
Cannon	0.00	0.29	0.05	0.00	0.00	0.00	0.00	0.18	1.52
Carroll	753.57	181.98	393.78	949.96	0.09	0.00	393.79	622.71	66.57
Carter	0.00	1.07	3.87	25.20	0.00	0.00	3.89	3.05	234.89
Cheatham	0.00	17.77	6.39	7.21	0.00	0.00	6.40	0.00	39.78
Chester	0.42	8.51	47.09	309.26	0.00	0.00	47.09	121.00	6.90
Claiborne	0.00	0.58	722.99	89.46	0.00	0.00	723.00	354.00	236.55
Clay	0.00	0.19	3.59	26.25	0.00	0.00	3.59	0.64	48.90
Cocke	0.00	50.37	234.06	50.32	0.00	0.00	234.07	109.53	172.72
Coffee	0.77	235.78	1134.45	624.67	0.07	0.00	1134.42	538.09	133.71
Crockett	4.79	606.70	279.58	1438.73	74.56	3.21	414.31	639.13	1146.35
Cumberland	122.03	75.86	616.30	111.32	0.00	0.00	616.32	215.99	743.32
Davidson	0.00	44.39	70.20	44.68	0.56	0.00	70.60	1.57	580.52
Decatur	0.00	0.26	463.54	431.31	0.00	0.00	463.55	271.42	22.53
De Kalb	20.17	34.95	523.43	193.68	0.00	0.00	523.44	241.65	82.07
Dickson	0.00	0.75	417.82	1469.92	22.69	0.00	417.92	478.68	121.49
Dyer	108.65	820.93	43.80	709.17	64.59	0.00	85.46	56.80	480.23
Fayette	196.59	717.27	46.08	1040.18	11.52	8.52	50.00	392.18	145.26
Fentress	0.00	0.37	35.70	345.96	0.00	0.00	35.71	207.49	54.49
Franklin	1.28	421.08	1953.36	50.92	0.17	3.59	1953.38	632.17	161.32
Gibson	1672.92	1789.78	1300.77	3528.77	188.65	0.75	1507.40	2033.06	205.27
Giles	0.77	0.69	204.07	710.07	14.55	0.00	204.08	40.19	93.22
Grainger	0.00	1.95	262.51	127.99	0.00	0.00	262.52	115.93	256.73
Greene	0.74	120.34	564.81	89.41	0.06	0.00	563.78	280.37	1129.14
Grundy	0.00	253.53	240.00	66.78	0.00	0.00	240.00	155.62	24.83
Hamblen	0.00	75.11	288.80	46.87	0.00	0.00	323.90	124.82	319.04
Hamilton	0.00	6.59	57.69	14.71	0.08	0.00	57.07	0.93	260.72
Hancock	0.00	0.00	12.07	69.47	0.00	0.00	12.07	4.60	217.79
Hardeman	59.34	402.29	145.78	970.68	7.62	0.00	145.79	656.49	228.09
Hardin	0.92	323.06	0.25	326.04	0.16	0.00	2.78	151.38	53.39
Hawkins	0.00	0.97	347.10	129.58	0.00	0.00	347.12	131.02	348.25
Haywood	153.39	466.03	123.94	3550.96	16.90	0.00	206.89	1368.29	44.24
Henderson	70.19	111.01	243.35	1184.40	0.07	0.00	243.36	595.47	92.76
Henry	671.95	782.66	382.81	1153.00	0.57	0.00	382.82	654.65	141.66
Hickman	0.00	0.39	401.61	245.82	0.00	0.00	401.65	118.86	25.43
Houston	60.66	0.17	0.72	217.72	0.00	0.00	0.72	57.37	86.55
Humphreys	102.26	5.87	282.16	406.19	0.00	0.00	282.16	334.26	27.73
Jackson	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	1.41
Jefferson	0.00	82.56	509.01	56.24	0.00	0.00	509.03	189.95	247.61
Johnson	0.00	0.31	0.00	117.17	0.00	0.00	0.00	1.99	142.40
Knox	0.00	6.99	356.03	104.15	0.53	0.00	351.95	277.30	583.75
Lake	287.91	568.31	421.60	1312.09	170.47	0.00	425.70	139.52	60.15
Lauderdale	71.52	519.12	1025.38	826.38	83.23	6.22	1025.39	296.29	112.54
Lawrence	306.24	284.29	245.71	1513.08	1.31	0.61	228.86	622.48	484.32
Lewis	0.00	0.21	0.00	14.39	0.00	0.00	0.00	1.07	31.89
Lincoln	1.00	416.64	777.73	950.30	1.35	15.23	777.74	311.71	157.68
Loudon	0.00	0.68	3.42	0.44	0.00	0.00	3.43	0.18	44.77
McMinn	0.48	51.58	2222.54	82.74	0.00	0.00	2222.51	597.44	181.24

Table A3. Activity level for Fertilizer by county in Tennessee (Cont.)

CNTY_NAME	Anhydrous Ammonia(ton)	Nitrogen Solutions(ton)	Urea (ton)	Ammonium Nitrate (ton)	Ammonium Sulfate (ton)	Ammonium Thiosulfate (ton)	Other Straight Nitrogen (ton)	Ammonium Phosphates (ton)	N-P-K (ton)
McNairy	51.85	84.70	35.70	397.76	0.05	0.00	35.71	340.70	51.24
Macon	0.00	0.41	1098.76	885.31	0.00	0.00	1098.77	547.46	37.59
Madison	2.27	419.05	0.00	1140.87	60.73	0.00	0.00	533.20	160.54
Marion	0.00	0.56	240.76	93.91	0.00	0.00	240.77	107.82	20.89
Marshall	0.50	17.61	148.98	1038.05	0.00	0.00	149.06	212.69	32.88
Maury	0.74	470.08	149.63	1293.04	0.06	0.00	149.65	64.85	129.63
Meigs	0.00	0.22	0.04	0.48	0.00	0.00	0.00	0.13	1.11
Monroe	0.00	0.72	750.51	41.41	0.00	0.00	750.52	354.80	111.25
Montgomery	87.76	979.62	323.71	904.98	0.52	3.28	323.77	543.75	683.81
Moore	0.00	0.00	0.00	0.73	0.00	0.00	0.00	0.00	3.14
Morgan	0.00	0.38	5.43	2.12	0.00	0.00	5.44	0.00	69.69
Obion	3284.99	1374.21	344.51	4677.80	279.31	0.00	710.18	2185.59	134.19
Overton	0.00	0.40	216.87	415.19	0.00	0.00	216.88	347.08	111.88
Perry	7.99	0.18	145.49	75.63	0.00	0.00	145.49	77.45	22.71
Pickett	0.00	0.00	0.57	7.11	0.00	0.00	0.57	0.29	19.00
Polk	0.00	0.31	10.33	2.92	0.00	0.00	10.33	2.94	15.15
Putnam	0.00	12.06	1003.73	459.46	0.00	0.00	1003.76	430.61	166.85
Rhea	0.00	0.57	0.06	0.00	0.00	0.00	0.00	0.18	13.98
Roane	0.00	0.98	114.53	11.15	0.00	0.00	114.55	65.90	65.67
Robertson	525.51	1331.80	1476.63	361.44	0.54	6.28	1476.65	889.21	773.44
Rutherford	0.54	81.19	2088.31	1250.58	0.14	25.26	2092.34	731.48	565.72
Scott	0.00	0.41	94.45	82.02	0.00	0.00	94.46	56.19	134.63
Sequatchie	0.00	0.20	176.68	37.88	0.00	0.00	176.69	51.73	5.94
Sevier	0.00	1.07	284.70	100.05	0.00	0.00	284.72	104.89	136.77
Shelby	20.88	228.28	1232.56	252.92	11.40	3.03	1200.40	62.66	2075.13
Smith	0.00	0.32	428.23	221.72	0.00	0.00	428.24	54.87	24.80
Stewart	0.00	0.22	0.39	4.26	0.00	0.00	0.40	3.62	15.12
Sullivan	0.00	3.05	39.08	63.61	0.09	0.00	39.15	9.73	304.67
Sumner	47.67	25.32	100.14	401.75	0.12	0.00	100.30	54.40	121.46
Tipton	4.60	1647.43	800.09	4367.23	45.43	2.35	855.68	1179.74	344.85
Trousdale	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.51
Unicoi	0.00	0.34	0.00	11.41	0.00	0.00	0.00	0.38	45.01
Union	0.00	15.15	336.04	44.85	0.00	0.00	336.05	117.60	64.34
Van Buren	0.00	0.00	0.19	2.63	0.00	0.00	0.19	0.19	7.22
Warren	0.44	31.75	44.22	884.41	0.12	0.00	44.24	455.60	415.91
Washington	0.00	2.63	476.72	436.40	0.00	0.00	472.83	295.99	1490.32
Wayne	0.00	0.35	306.53	324.03	0.00	0.00	292.54	293.09	27.97
Weakley	2284.26	520.97	658.74	1512.15	67.16	2.60	723.06	927.56	320.52
White	0.00	0.48	378.99	160.79	15.37	0.00	379.00	192.89	658.31
Williamson	0.00	53.09	38.75	537.79	0.15	0.00	38.22	35.36	217.17
Wilson	0.00	1.49	361.08	376.31	0.00	0.00	361.11	143.15	44.03
Total	10989.00	16948.35	33869.11	50307.73	1141.08	80.93	34625.34	26887.09	20817.22

Table A4. Activity level for Onroad Mobile Sources by county in Tennessee

CNTYNAME	LDGV DVMT (miles /day)	LDGT 12 DVMT (miles /day)	LDGT 34 DVMT (miles /day)	HDGV DVMT (miles /day)	MC DVMT (miles /day)	LDDV DVMT (miles /day)	LDDT DVMT (miles /day)	HDDV DVMT (miles /day)
Anderson	1244775.19	690254.10	234148.64	37878.46	10048.21	5272.29	5367.32	183612.89
Bedford	464463.02	325547.11	110721.89	9485.98	3999.13	2193.63	2813.32	46330.66
Benton	344098.92	241074.95	81931.75	18829.49	4654.05	1625.33	2082.42	90409.76
Bledsoe	116361.08	81557.36	27804.03	2453.44	1155.38	549.55	705.73	11804.37
Blount	1345025.36	745717.89	253260.82	23494.31	7367.50	5696.62	5803.08	114533.61
Bradley	1208767.83	846867.14	287338.36	57160.06	13201.57	5709.49	7308.66	275935.17
Campbell	809095.04	566963.04	191697.81	60106.20	12300.73	2260.34	3572.21	288883.35
Cannon	149801.60	104995.78	35794.51	3158.52	1487.42	707.49	908.55	15196.78
Carroll	404071.42	283207.32	96477.32	9242.72	3968.22	1908.39	2449.62	44601.70
Carter	664448.97	375522.04	127436.66	11934.91	4487.25	3514.64	3264.37	58765.15
Cheatham	546770.86	383027.97	130081.47	34221.40	7855.12	2582.71	3307.27	164287.38
Chester	191900.51	134502.86	45853.88	4046.17	1905.43	906.32	1163.88	19467.55
Claiborne	389041.41	272678.70	92959.93	8202.82	3862.89	1837.38	2359.54	39466.72
Clay	86422.51	60573.45	20650.32	1822.19	858.11	408.16	524.15	8767.22
Cocke	555986.19	389485.00	132174.20	33144.48	7382.10	2626.23	3361.63	159419.96
Coffee	936068.99	656027.63	221841.27	55539.26	11777.38	2615.28	4133.64	267649.90
Crockett	230110.83	161284.43	54984.09	4851.82	2284.83	1086.78	1395.62	23343.84
Cumberland	980175.74	686903.37	232344.76	63022.67	13306.45	2738.40	4329.08	303200.37
Davidson	12285423.52	4958691.22	1662589.16	331504.10	50974.66	33916.86	30750.67	1594617.82
Decatur	250147.13	175249.49	59552.84	14028.51	3419.69	1181.56	1513.71	67355.77
DeKalb	202657.44	142042.38	48424.21	4272.97	2012.24	957.12	1229.12	20558.80
Dickson	733040.79	513604.53	174367.62	35701.62	8789.82	3462.44	4433.95	172153.79
Dyer	571901.53	400787.23	136228.18	17346.73	5495.28	2701.14	3462.34	84065.80
Fayette	857857.52	311023.58	104900.93	42742.11	9031.26	2589.42	2032.40	205278.93
Fentress	198056.87	138817.85	47324.92	4175.97	1966.56	935.39	1201.21	20092.09
Franklin	425324.59	298116.07	101493.42	8411.14	3838.08	2008.76	2577.70	40862.71
Gibson	585382.97	410304.50	139661.87	11471.79	5210.05	2764.70	3547.38	55810.76
Giles	561139.32	393142.37	133549.41	29754.01	7304.35	2650.50	3395.09	143086.49
Grainger	316256.27	221663.68	75568.20	6668.17	3140.19	1493.63	1918.09	32082.95
Greene	1101568.09	771804.37	261977.38	55393.65	13436.03	5203.17	6662.29	267114.54
Grundy	215114.14	150698.02	51190.55	12941.61	3034.60	1016.10	1301.37	62131.86
Hamblen	787435.79	551843.06	187225.00	25220.73	7191.28	3719.21	4762.36	123038.11
Hamilton	5410176.54	2727974.47	927225.93	163936.54	26943.30	23285.67	20721.73	805087.39
Hancock	51969.88	36425.63	12418.00	1095.77	516.02	245.45	315.20	5272.14
Hardeman	350554.77	245706.96	83690.59	7092.61	3274.11	1655.62	2125.10	34336.35
Hardin	342328.74	239942.04	81710.40	6859.46	3151.13	1616.77	2075.00	33256.81
Hawkins	636996.08	360176.63	122346.24	11054.49	4958.58	3369.42	3132.73	53978.98
Haywood	547271.36	383500.33	129667.68	39905.53	8206.70	1528.90	2416.29	191842.08
Henderson	709323.40	497100.35	168168.23	47055.76	10112.19	1981.64	3133.22	226303.01
Henry	431211.00	302243.55	102864.31	8389.60	3795.77	2036.56	2612.90	40862.08
Hickman	443877.06	310949.08	105605.04	27666.15	6364.58	2096.68	2684.94	132818.09
Houston	71742.64	50284.34	17142.62	1512.67	712.35	338.83	435.12	7278.01
Humphreys	406062.21	284456.79	96603.12	25517.23	5844.61	1918.06	2456.12	122500.55
Jackson	129783.97	90965.45	31011.38	2736.46	1288.66	612.95	787.14	13166.07
Jefferson	1133805.32	628939.43	212969.20	59030.21	14463.28	4802.56	4884.66	285259.44
Johnson	178524.27	125127.47	42657.68	3764.13	1772.61	843.14	1082.75	18110.59
Knox	6531197.71	3615321.77	1225919.13	208582.04	37080.99	27662.02	28104.85	1013794.44
Lake	55398.70	38828.89	13237.30	1168.07	550.07	261.64	335.99	5619.98
Lauderdale	323924.91	227045.24	77262.26	6264.56	2825.31	1529.86	1962.68	30540.83
Lawrence	451036.39	316139.54	107593.27	8773.95	3969.34	2130.19	2733.03	42735.15
Lewis	98258.54	68869.31	23478.50	2071.75	975.63	464.06	595.94	9967.94
Lincoln	395451.83	277178.89	94342.70	7729.22	3505.45	1867.67	2396.34	37618.56
Loudon	1011775.86	561199.18	190024.49	52525.06	12690.99	4285.68	4358.48	253841.12

Table A4. Activity level for Onroad Mobile Sources by county in Tennessee (Cont.)

CNTYNAME	LDGV DVMT (miles /day)	LDGT 12 DVMT (miles /day)	LDGT 34 DVMT (miles /day)	HDGV DVMT (miles /day)	MC DVMT (miles /day)	LDDV DVMT (miles /day)	LDDT DVMT (miles /day)	HDDV DVMT (miles /day)
McMinn	989173.18	692951.91	235124.20	57998.23	12886.29	4672.41	5980.38	279106.14
McNairy	398295.74	279165.05	95171.22	8397.95	3954.78	1881.09	2415.66	40405.54
Macon	190828.05	133751.18	45597.62	4023.55	1894.78	901.25	1157.37	19358.76
Madison	1703027.16	1193271.30	404708.72	67485.23	16259.49	8043.92	10295.96	327356.66
Marion	958586.05	485517.62	163670.79	63209.58	13197.67	4124.90	3669.22	303816.38
Marshall	444624.35	311540.25	105810.13	20331.68	5245.32	2100.11	2690.14	98050.10
Maury	1160939.20	813509.89	276266.43	42181.15	11587.58	5483.36	7024.28	204258.38
Meigs	128722.85	90221.71	30757.83	2714.08	1278.12	607.94	780.70	13058.43
Monroe	539427.78	377992.64	128545.54	21313.21	6170.36	2547.82	3266.31	102625.43
Montgomery	1530104.36	1072209.51	363579.79	44248.26	11476.57	7226.94	9250.52	216459.29
Moore	71080.79	49820.45	16984.48	1498.72	705.78	335.70	431.10	7210.87
Morgan	184089.08	129027.84	43987.37	3881.46	1827.87	869.42	1116.50	18675.11
Obion	506372.95	354924.66	120820.15	9958.78	4531.30	2391.54	3068.70	48422.99
Overton	276743.33	193969.10	66126.74	5835.05	2747.86	1307.01	1678.45	28074.52
Perry	110214.03	77248.90	26335.21	2323.83	1094.34	520.52	668.45	11180.78
Picket	58785.47	41202.67	14046.56	1239.47	583.70	277.63	356.53	5963.55
Polk	241102.78	168988.68	57610.57	5083.58	2393.97	1138.69	1462.29	24458.93
Putnam	1134926.99	795260.36	268791.59	75685.99	14757.56	3170.88	5009.24	364195.15
Rhea	343063.55	240458.60	81853.91	6743.89	3067.77	1620.25	2079.01	32793.45
Roane	891953.94	625146.42	211503.23	49199.79	10899.44	2492.02	3940.44	237139.54
Robertson	1035960.94	725973.70	245534.11	72834.39	15270.04	2894.15	4575.02	350148.47
Rutherford	3342649.89	1351085.60	453395.16	103695.14	25311.70	9227.65	8383.62	498958.02
Scott	226107.53	158478.52	54027.51	4767.41	2245.08	1067.87	1371.34	22937.72
Sequatchie	173483.26	121594.23	41453.15	3657.84	1722.56	819.33	1052.18	17599.19
Sevier	1289742.29	715280.58	242813.87	33689.59	10243.27	5462.47	5564.27	163542.46
Shelby	15149420.00	5451220.82	1829927.20	288194.78	67226.79	45724.68	35500.92	1402495.91
Smith	475137.02	332937.63	112639.47	36160.62	7505.64	1327.33	2098.65	173562.01
Stewart	150112.01	105213.35	35868.68	3165.07	1490.50	708.95	910.43	15228.27
Sullivan	2345690.26	1325648.18	449159.40	66148.45	14520.41	12407.87	11513.94	322605.95
Sumner	2073994.74	835118.99	282160.95	55154.39	12793.15	5725.46	5210.15	270097.91
Tipton	639515.02	231456.46	78075.78	9637.41	4395.44	1930.41	1512.25	45710.13
Trousdale	106702.83	74787.90	25496.23	2249.80	1059.48	503.94	647.15	10824.58
Unicoi	259811.82	146969.60	49957.37	4811.41	2231.66	1374.28	1278.84	23258.75
Union	168061.04	93253.01	31677.06	4122.88	1525.77	711.76	725.69	20019.15
Van Buren	80382.74	56340.17	19207.14	1694.85	798.14	379.63	487.52	8154.51
Warren	474497.19	332585.14	113158.50	9102.54	4087.41	2241.00	2874.75	44433.55
Washington	1469327.19	830478.39	281450.98	41642.42	9394.80	7772.21	7214.16	202714.68
Wayne	187466.05	131394.76	44794.28	3952.67	1861.40	885.37	1136.98	19017.69
Weakley	386556.94	270942.25	92263.82	7731.76	3548.62	1825.66	2343.04	37496.36
White	285988.30	200448.89	68335.79	6029.98	2839.65	1350.68	1734.52	29012.39
Williamson	2312157.96	934259.31	313370.42	61643.69	16222.71	6382.51	5795.35	298855.08
Wilson	1971021.52	795423.27	267964.39	70773.29	14375.07	5441.46	4950.76	339602.60
Total	**95935210.79**	**51179423.32**	**17317516.82**	**3115173.16**	**736977.39**	**361250.47**	**386210.75**	**15067001.85**

Table A5. Activity level for Human Sources by county in Tennessee

CNTY_NAME	1999 Population	1999 Infant (0-3 yrs)	1999 Disposable Diapers	1999 Cloth Diapers	1999 Homeless	1999 Smoking Cigarette
Anderson	71004	3399	3059.1	339.90	355	13617
Bedford	34905	1892	1702.8	189.20	175	6504
Benton	16497	721	648.9	72.10	82	3199
Bledsoe	10945	518	466.2	51.80	55	2081
Blount	102785	4996	4496.4	499.60	514	19837
Bradley	84126	4117	3705.3	411.70	421	16026
Campbell	38466	1935	1741.5	193.50	192	7199
Cannon	12248	602	541.8	60.20	61	2303
Carroll	29450	1411	1269.9	141.10	147	5639
Carter	53299	2360	2124	236.00	266	10453
Cheatham	36128	2240	2016	224.00	181	6533
Chester	14859	749	674.1	74.90	74	2823
Claiborne	29747	1448	1303.2	144.80	149	5573
Clay	7268	303	272.7	30.30	36	1400
Cocke	32291	1459	1313.1	145.90	161	6184
Coffee	46355	2510	2259	251.00	232	8686
Crockett	14077	661	594.9	66.10	70	2654
Cumberland	45326	2073	1865.7	207.30	227	8817
Davidson	530050	29570	26613	2957.00	2650	102217
Decatur	16174	791	711.9	79.10	81	3077
De Kalb	10788	438	394.2	43.80	54	2092
Dickson	43017	2536	2282.4	253.60	215	7824
Dyer	36725	1938	1744.2	193.80	184	6820
Fayette	31441	1832	1648.8	183.20	157	5517
Fentress	16357	780	702	78.00	82	3051
Franklin	37826	1776	1598.4	177.60	189	7222
Gibson	48030	2272	2044.8	227.20	240	9159
Giles	29036	1514	1362.6	151.40	145	5452
Grainger	20219	963	866.7	96.30	101	3845
Greene	60900	2654	2388.6	265.40	305	11860
Grundy	14046	693	623.7	69.30	70	2556
Hamblen	54201	2591	2331.9	259.10	271	10415
Hamilton	294720	15045	13540.5	1504.50	1474	56270
Hancock	6767	328	295.2	32.80	34	1270
Hardeman	24451	1381	1242.9	138.10	122	4387
Hardin	25247	1245	1120.5	124.50	126	4778
Hawkins	50109	2315	2083.5	231.50	251	9642
Haywood	19416	1059	953.1	105.90	97	3430
Henderson	24767	1212	1090.8	121.20	124	4671
Henry	30091	1342	1207.8	134.20	150	5822
Hickman	21283	1086	977.4	108.60	106	4052
Houston	7888	362	325.8	36.20	39	1502
Humphreys	17192	794	714.6	79.40	86	3252
Jackson	9643	395	355.5	39.50	48	1865
Jefferson	45104	1918	1726.2	191.80	226	8843
Johnson	16736	694	624.6	69.40	84	3300
Knox	376039	19162	17245.8	1916.20	1880	72995
Lake	8131	288	259.2	28.80	41	1668
Lauderdale	24234	1328	1195.2	132.80	121	4389
Lawrence	39626	2290	2061	229.00	198	7354
Lewis	11127	582	523.8	58.20	56	2031
Lincoln	29773	1519	1367.1	151.90	149	5631
Loudon	39892	1928	1735.2	192.80	199	7732

Table A5. Activity level for Human Sources by county in Tennessee (Cont.)

CNTY_NAME	1999 Population	1999 Infant (0-3 yrs)	1999 Disposable Diapers	1999 Cloth Diapers	1999 Homeless	1999 Smoking Cigarette
McMinn	18542	995	896	100	93	4212
McNairy	86752	4962	4466	496	434	16024
Macon	26907	1369	1232	137	135	5007
Madison	26423	1316	1184	132	132	4916
Marion	70440	3880	3492	388	352	13007
Marshall	46395	2222	2000	222	232	8817
Maury	24312	1110	999	111	122	4629
Meigs	10134	453	408	45	51	1915
Monroe	35576	1839	1655	184	178	6666
Montgomery	129411	9521	8569	952	647	23403
Moore	5140	233	210	23	26	966
Morgan	18689	906	815	91	93	3490
Obion	32240	1458	1312	146	161	6090
Overton	19654	884	796	88	98	3745
Perry	7560	411	370	41	38	1430
Pickett	4711	230	207	23	24	893
Polk	15094	650	585	65	75	2891
Putnam	59735	2914	2623	291	299	11626
Rhea	28116	1385	1247	139	141	5287
Roane	50008	2245	2021	225	250	9698
Robertson	54861	3306	2975	331	274	9970
Rutherford	171401	10646	9581	1065	857	31099
Scott	20239	1148	1033	115	101	3595
Sequatchie	10846	543	489	54	54	2029
Sevier	65783	3134	2821	313	329	12627
Shelby	873000	53687	48318	5369	4365	158581
Smith	16771	914	823	91	84	3144
Stewart	11759	464	418	46	59	2289
Sullivan	150231	6736	6062	674	751	29470
Sumner	126009	6944	6250	694	630	23060
Tipton	48348	3201	2881	320	242	8423
Trousdale	6971	326	293	33	35	1313
Unicoi	17310	714	643	71	87	3415
Union	16584	919	827	92	83	3053
Van Buren	5008	260	234	26	25	933
Warren	36421	1844	1660	184	182	6856
Washington	102814	4751	4276	475	514	20142
Wayne	16413	768	691	77	82	3157
Weakley	32952	1529	1376	153	165	6414
White	22864	1109	998	111	114	4373
Williamson	123793	7003	6303	700	619	22277
Wilson	86496	4880	4392	488	432	15807
Total	**5483535**	**293824**	**264442**	**29382**	**27418**	**1032256**

Table A6. Activity level for Domestic Animals by county in Tennessee

CNTY_NAME	1999 Dogs	1999 Cats
Anderson	14308	16023
Bedford	7034	7877
Benton	3324	3723
Bledsoe	2206	2470
Blount	20712	23195
Bradley	16952	18984
Campbell	7751	8680
Cannon	2468	2764
Carroll	5934	6646
Carter	10740	12027
Cheatham	7280	8153
Chester	2994	3353
Claiborne	5994	6713
Clay	1465	1640
Cocke	6507	7287
Coffee	9341	10460
Crockett	2837	3177
Cumberland	9134	10228
Davidson	106810	119611
Decatur	3259	3650
De Kalb	2174	2434
Dickson	8668	9707
Dyer	7400	8287
Fayette	6336	7095
Fentress	3296	3691
Franklin	7622	8536
Gibson	9678	10838
Giles	5851	6552
Grainger	4074	4563
Greene	12272	13743
Grundy	2830	3170
Hamblen	10922	12231
Hamilton	59389	66507
Hancock	1364	1527
Hardeman	4927	5518
Hardin	5088	5697
Hawkins	10097	11308
Haywood	3913	4381
Henderson	4991	5589
Henry	6064	6790
Hickman	4289	4803
Houston	1590	1780
Humphreys	3464	3880
Jackson	1943	2176
Jefferson	9089	10178
Johnson	3372	3777
Knox	75775	84857
Lake	1638	1835
Lauderdale	4883	5469
Lawrence	7985	8942
Lewis	2242	2511

Table A6. Activity level for Domestic Animals by county in Tennessee (Cont.)

CNTY_NAME	1999 Dogs	1999 Cats
Lincoln	6000	6719
Loudon	8039	9002
McMinn	3736	4184
McNairy	17481	19576
Macon	5422	6072
Madison	5324	5963
Marion	14194	15896
Marshall	9349	10470
Maury	4899	5486
Meigs	2042	2287
Monroe	7169	8028
Montgomery	26078	29203
Moore	1036	1160
Morgan	3766	4217
Obion	6497	7275
Overton	3960	4435
Perry	1523	1706
Pickett	949	1063
Polk	3042	3406
Putnam	12037	13480
Rhea	5666	6345
Roane	10077	11285
Robertson	11055	12380
Rutherford	34539	38678
Scott	4078	4567
Sequatchie	2186	2448
Sevier	13256	14845
Shelby	175918	197002
Smith	3380	3785
Stewart	2370	2654
Sullivan	30273	33901
Sumner	25392	28435
Tipton	9743	10910
Trousdale	1405	1573
Unicoi	3488	3906
Union	3342	3742
Van Buren	1009	1130
Warren	7339	8219
Washington	20718	23201
Wayne	3307	3704
Weakley	6640	7436
White	4607	5159
Williamson	24945	27935
Wilson	17430	19519
Total	**1104984**	**1237417**

Table A7. Activity level for Wild Animals by county in Tennessee

CNTY_NAME	BlackBears	Deer
Anderson	11	8136
Bedford	5	3865
Benton	13	9825
Bledsoe	13	9731
Blount	15	11279
Bradley	8	5885
Campbell	19	13787
Cannon	6	4388
Carroll	12	8932
Carter	13	9398
Cheatham	9	6660
Chester	8	5648
Claiborne	12	9179
Clay	7	5268
Cocke	14	10565
Coffee	8	5848
Crockett	1	680
Cumberland	24	17942
Davidson	9	6941
Decatur	11	8123
De Kalb	8	5936
Dickson	14	10222
Dyer	3	2515
Fayette	11	8111
Fentress	18	13424
Franklin	13	9803
Gibson	3	2015
Giles	12	8529
Grainger	7	5022
Greene	9	6941
Grundy	14	10438
Hamblen	2	1353
Hamilton	15	11145
Hancock	7	4948
Hardeman	18	13507
Hardin	17	12764
Hawkins	12	9155
Haywood	5	3826
Henderson	14	10320
Henry	9	6818
Hickman	22	16015
Houston	7	5225
Humphreys	18	13542
Jackson	10	7428
Jefferson	4	3139
Johnson	10	7275
Knox	9	6333
Lake	1	534
Lauderdale	7	5228
Lawrence	14	10107

Table A7. Activity level for Wild Animals by county in Tennessee (Cont.)

CNTY_NAME	BlackBears	Deer
Lewis	11	8127
Lincoln	8	6212
Loudon	4	2835
McMinn	10	7377
McNairy	17	12375
Macon	7	5172
Madison	9	6886
Marion	20	14507
Marshall	6	4390
Maury	11	7804
Meigs	6	4296
Monroe	22	16324
Montgomery	11	7804
Moore	2	1722
Morgan	21	15531
Obion	3	2581
Overton	12	9002
Perry	16	11721
Pickett	5	4004
Polk	18	13042
Putnam	9	7013
Rhea	10	7176
Roane	12	8614
Robertson	3	2347
Rutherford	9	6883
Scott	23	16888
Sequatchie	10	7440
Sevier	20	15127
Shelby	9	6524
Smith	6	4448
Stewart	18	13294
Sullivan	9	6570
Sumner	8	5594
Tipton	4	3025
Trousdale	2	1505
Unicoi	8	6129
Union	6	4698
Van Buren	10	7357
Warren	7	5345
Washington	4	2663
Wayne	28	20765
Weakley	4	2949
White	9	6511
Williamson	11	8134
Wilson	10	7555
Total	1000	739960

Table A8. Activity level for POTW by county in Tennessee

CNTY_NAME	POTW Flow (MGD)	CNTY_NAME	POTW Flow (MGD)
Anderson	8.835	Lincoln	2.099
Bedford	2.087	Loudon	6.598
Benton	0.278	McMinn	4.905
Bledsoe	0.509	McNairy	1.588
Blount	6.309	Macon	0.788
Bradley	8.539	Madison	10.078
Campbell	1.907	Marion	0.818
Cannon	0.349	Marshall	2.537
Carroll	1.706	Maury	4.897
Carter	1.639	Meigs	0.119
Cheatham	0.698	Monroe	2.377
Chester	0.357	Montgomery	8.071
Claiborne	0.967	Moore	0.323
Clay	0.219	Morgan	0.388
Cocke	2.319	Obion	3.545
Coffee	5.578	Overton	1.579
Crockett	0.726	Perry	0.448
Cumberland	2.968	Pickett	0.289
Davidson	153.426	Polk	0.398
Decatur	0.458	Putnam	7.338
De Kalb	0.978	Rhea	1.778
Dickson	1.217	Roane	3.765
Dyer	4.627	Robertson	4.078
Fayette	1.665	Rutherford	10.298
Fentress	0.619	Scott	0.797
Franklin	1.496	Sequatchie	0.75
Gibson	4.973	Sevier	6.656
Giles	2.019	Shelby	187.385
Grainger	0.079	Smith	0.568
Greene	3.347	Stewart	0.149
Grundy	0.191	Sullivan	21.308
Hamblen	2.829	Sumner	3.126
Hamilton	62.938	Tipton	1.969
Hancock	0.139	Trousdale	0.289
Hardeman	1.195	Unicoi	1.489
Hardin	1.777	Union	0.349
Hawkins	1.658	Van Buren	0
Haywood	1.118	Warren	3.008
Henderson	2.679	Washington	8.606
Henry	2.538	Wayne	0.795
Hickman	0.359	Weakley	1.705
Houston	0.109	White	0.739
Humphreys	1.658	Williamson	2.747
Jackson	0.239	Wilson	3.927
Jefferson	1.077	**Total**	695.256
Johnson	1.399		
Knox	62.102		
Lake	0.598		
Lauderdale	1.508		
Lawrence	2.018		
Lewis	0.769		

Table A9. Activity level for Biomass Burning by county in Tennessee

CNTY_NAME	FireAcres	FuelLoad (tons/acre)	CNTY_NAME	FireAcres	FuelLoad (tons/acre)
Anderson	357	9	Lewis	295	9
Bedford	497	9	Lincoln	607	9
Benton	444	9	Loudon	262	9
Bledsoe	425	9	McMinn	448	9
Blount	595	9	McNairy	582	9
Bradley	348	9	Macon	328	9
Campbell	518	9	Madison	588	9
Cannon	265	9	Marion	548	9
Carroll	632	9	Marshall	384	9
Carter	377	9	Maury	638	9
Cheatham	319	9	Meigs	225	9
Chester	301	9	Monroe	693	9
Claiborne	476	9	Montgomery	576	9
Clay	269	9	Moore	135	9
Cocke	475	9	Morgan	541	9
Coffee	447	9	Obion	581	9
Crockett	271	9	Overton	454	9
Cumberland	714	9	Perry	430	9
Davidson	552	9	Pickett	187	9
Decatur	368	9	Polk	460	9
De Kalb	347	9	Putnam	422	9
Dickson	510	9	Rhea	355	9
Dyer	551	9	Roane	409	9
Fayette	730	9	Robertson	516	9
Fentress	516	9	Rutherford	639	9
Franklin	592	9	Scott	560	9
Gibson	633	9	Sequatchie	278	9
Giles	655	9	Sevier	633	9
Grainger	316	9	Shelby	826	9
Greene	647	9	Smith	327	9
Grundy	382	9	Stewart	521	9
Hamblen	182	9	Sullivan	444	9
Hamilton	620	9	Sumner	579	9
Hancock	227	9	Tipton	462	9
Hardeman	698	9	Trousdale	124	9
Hardin	619	9	Unicoi	209	9
Hawkins	514	9	Union	250	9
Haywood	569	9	Van Buren	263	9
Henderson	545	9	Warren	466	9
Henry	611	9	Washington	342	9
Hickman	646	9	Wayne	769	9
Houston	215	9	Weakley	593	9
Humphreys	581	9	White	398	9
Jackson	333	9	Williamson	607	9
Jefferson	328	9	Wilson	597	9
Johnson	320	9	**Total**	**44016**	
Knox	548	9			
Lake	203	9			
Lauderdale	522	9			
Lawrence	655	9			

VITA

Yunhee Kim was born in Pusan, South Korea on August 26, 1968. She enrolled in the Environmental Engineering program at Pukyoung University, Pusan in South Korea in 1987. She graduated from the University of Pukyong, Pusan in South Korea with a B.S. degree in Environmental Engineering in February 1991.

She then worked for Han-Sung and Dae-Kwang Environmental Engineering companies to get experience as an environmental engineer in South Korea for 7 years. After that, she came to the United States to learn English and to pursue advanced studies in 1998.

In Summer 2000, she enrolled in the graduate program in the Department of Civil and Environmental Engineering at the University of Tennessee, Knoxville and accepted a graduate research assistantship from the department. She received her M.S degree in Environmental Engineering, with a concentration in Air Quality from the University of Tennessee, Knoxville in May 2003. She will continue her studies in the PhD program in the Department of Civil and Environmental Engineering at the University of Tennessee, Knoxville in Summer 2003.